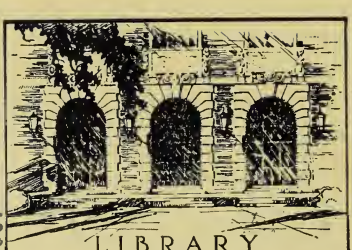

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OF THE

ILLINOIS STATE ACADEMY OF SCIENCE

VOLUME 40 1947

Fortieth Annual Meeting

Peoria, Illinois

May, 1947

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14

TRANSACTIONS OF THE ILLINOIS ACADEMY OF SCIENCE
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Contents

MORNING ADDRESS

Page

McGregor, J. C., Archeology and social change 9

ARCHAEOLOGY AND ANTHROPOLOGY

Horner, George R., An upper Mississippi house-pit from the Fisher village site: Further evidence 26
Maxwell, Moreau S., The succession of woodland horizons in the Carbondale area 30
Schoenbeck, E., A seven-pound copper axe among 1946 Hopewell discoveries 36

BOTANY

Arzeni, Charles B., Some Bryophytes of Coles and Clark counties..... 44
Fuller, George D., Additions to the flora of Sangamon County, Illinois..... 50
Jones, George Neville, A revised checklist of the vascular plants of the University of Illinois woodlands 52
Peterson, Carroll J., A method for cytological investigation of algae..... 57
Schoenbeck, E., *Houstonia minima* in Peoria County..... 60
Sibert, Marvin, The control of weeds on a typical prairie farm..... 61
Spooner, Harry L., Virginius H. Chase, Peoria botanist..... 67
Winterringer, Glen, The Acanthaceae of Illinois..... 73

CHEMISTRY

Cagle, F. Wm., Jr., The use of partial differentials for the estimation of errors in volumetric analysis 80
Deanin, Rudolph, The chemistry of synthetic rubber..... 84

GEOGRAPHY

Garland, John H., Occupance patterns of the lower Illinois Valley..... 95
Lounsbury, John Frederick, The pottery industry in McDonough and Warren counties, Illinois 100
Pewe, Troy L., Teaching of conservation of natural resources in Illinois colleges and universities 107
Reith, John W., Lake Michigan ports: A classification by items of traffic..... 116

GEOLOGY

Atherton, Elwood, Some Chester outcrop and subsurface sections in southeastern Illinois 122
Bieber, C. L., Structural trends in the Pecatonica quadrangle based upon Decorah stratigraphy 132
Schweitzer, Geo. K. and Chapman, Carleton A., Geological applications of the ionic potential 137
Shrode, Raymond S., Unusual oolite grains from the Ste. Genevieve limestone 140

PHYSICS

Walker, H. L. and Baskal, M., Endurance limit of a free-cutting brass rod.... 146

PSYCHOLOGY AND EDUCATION

White, David Manning, Sex deviations in the selection of masculine and feminine words in poetry 152

SOCIAL SCIENCE

CAVAN, RUTH SHONLE, O'd age in a city of 100,000 156
LARDNER, LYNFORD A., A basic defect in the Illinois Constitution 171

ZOOLOGY

FAWVER, BEN J., Bird population of an Illinois floodplain forest 178
HOFFMEISTER, DONALD F., A concentration of Lemming mice *(Synaptomys cooperi)* in central Illinois 190
MILUM, VERN G., Grooming dance and associated activities of the honeybee colony 194
MOHR, CARL O., Major fluctuations of some Illinois mammal populations 197
WALTON, A. C., Parasites of the Hylidae (Amphibia-Hylinae). VI 205
WANTLAND, WAYNE W. and MARTIN, PAUL, An investigation of some possible sources of trichina infection in a central Illinois community 215
WEBB, GLENN R., Studies of the sex-organs of mating polygyrid landsnails 218
WETZEL, R. M., Additional records of Illinois mammals 228

COLLEGIATE SECTION

Papers presented at 40th annual meeting 234

MEMORIAL

ALBERT EDWARD EDGECOMBE, by Hanford Tiffany 236

ACADEMY BUSINESS

Secretary's report for the year 1946-1947 237

Leo R. Tehon, President, 1946-1947

MORNING ADDRESS

ARCHEOLOGY AND SOCIAL CHANGE

J. C. McGREGOR
Illinois State Museum, Springfield
First Vice-President, Illinois State Academy of Science

Just a year ago the retiring president, Dr. Emerson, read before this academy a thought provoking paper on the biological basis of social cooperation, wherein he stressed the crucial social problems then confronting humanity, suggesting certain biological and ecological principles which it was felt may bear on the interrelations of human society. The same appalling problems still confront us, with little change. Such being the case it may be profitable to continue this general discussion, somewhat in the nature of a running symposium, by bringing to the attention of this group the contributions of another field, that of archeology.

Man has undoubtedly been a subject of consuming interest to man since the beginning of human history, and there is little doubt that the human species has been subjected to a more searching examination than any other animal species. Every individual must necessarily spend a lifetime in the study of other people; yet with all this research and accumulated knowledge, society is repeatedly confronted with crises of various sorts, of which the present is beyond any question the most filled with promise of dire consequence. Many of us have heard the implied, or specific charge, that social science has failed miserably to keep stride with the development of the physical sciences.

Even if it be admitted that such a charge is true, and it probably is, it is somewhat unjust at a time when the physical sciences have enjoyed a war time stimulation far beyond their normal status, even in the present age. However, if a social atomic bomb is to be exploded in time to neutralize the effects of the physical atomic bomb, social thought must be revised as radically and put into effect as forcefully as thinking and action in the physical sciences. But society is resistant to social change, and if the necessary immediate readjustment is to be effected every effort must be made now to determine how such evolutionary processes function.

This paper does not attempt to answer all the social problems which are so urgently crying for solution; it rather points up the possible contributions of one small field to a better understanding of the mechanics of change. To do so, not only must the biological sciences be called upon for assistance, but all the physical and social sciences must be mobilized as well.

Archeological Aims and Methods

It has long been my conviction that the fundamentals of a complex society are generally obscured by the proliferation of incidentals, for it is so easy for an abundance of fascinating trees to obscure the broad outlines of the forest. Also, if we are ever to understand the operation of complex society, and all society is more or less complex, we must first study the more simple society and resolve it to understandable fundamentals. This principle has been subscribed to by a long and illustrious list of anthropologists, and is today reflected in the work of Redfield on the mechanics of social change the Maya are now undergoing, and by Kluckhohn in his long range Navaho studies at Ramah, New Mexico.

However, such studies are limited to a comparatively short span of observable time, and if we are to have the desirable depth of perspective of the evolution of simple society, so as to understand the mechanics of broad social change, we must of necessity employ history. Unfortunately it is a well known fact that simple society almost universally has no written history, and it is therefore necessary to turn to archeology to supply the missing pages in the record of the story of man.

Kluckhohn has expressed a critical attitude toward archeology when in 1940 he said:[1] "Do researches which require large funds for their support require no social justification other than that of quenching certain thirsts for knowledge on the part of a relatively small number of citizens? If archeologists and ethnologists have hardly begun to ask themselves the tough-minded query —so what?, evidence is not lacking that this question has occurred to research foundations and other sources of financial support. Personally, I suspect that unless archeologists treat their work quite firmly as part of a general attempt to understand social behavior they will before many generations, find themselves classed with Aldous Huxley's figure who devoted his life to writing a history of the three-pronged fork."

Just what is the case of archeology, and where does it stand among the sciences of the study of man today?

If we are willing at the outset to admit that the immediate aim of archeology is the re-creation of history from prehistoric data, and are willing to let universal laws become evident as a result of the study of these historical sequences, we may now proceed to a more careful examination of how history may be wrung from prehistory. The activities of man are apparent in two broad categories. 1. The material remains which result from his efforts at production or creation. These are known as material traits, and in our own society are rather fully represented by salable articles. 2. The mental attitudes, or non-material traits, which consist of such elusive qualities as the folkways, mores, laws, rules and regulations which control human relations.

It is obvious that the source data of true archeology, lacking all writ-

[1] Kluckhohn, Clyde, "The Conceptual Structure in Middle American Studies," From, "The Maya and their Neighbors," D. Appleton-Century Company, Inc., 35 W. 32nd St., N. Y. 1, New York, 1940. Page 43. (Permission to quote given in letter of May 12, 1947.)

ten history, is confined wholly to material traits, and because they are perishable many data are limited to the more resistant of even these traits. The preservation of any material through centuries depends on many factors, and at best only a small portion of any group survives. Thus, at the outset, the archeologist is limited to laboring with only a part of the tools available to other branches of social study. However, as will be demonstrated later, it is sometimes possible, through analogy with living groups, to suggest certain non-material traits.

One of the most vexing problems confronting every archeologist is the ordering of his data into relative and absolute temporal sequences. By comparison the equally necessary technique of arranging traits into typological sequences is a very simple matter. The most common and most satisfactory method of establishing relative chronology is by a study of stratigraphy, although other disciplines, such as geology and paleontology, chemistry in soil analysis, and even artifact sequences may also be of aid. In the Southwest, tree-ring dating revolutionized archeological research, and is in fact of such importance that I would like to take a few minutes to discuss it in some detail.

Dr. A. E. Douglass, a southwestern astronomer, in 1905 began study of tree growth, as reflected in their ring sizes, in an effort to correlate sun spot cycles with growth. With comparatively little effort, once suitable material was made available, he was able to demonstrate that rings grown in certain years were more or less consistently small, or large. However, he was unable to extend this record back for more than four or five hundred years.

Additional material, this time from prehistoric and ruined southwestern dwellings, was next secured. An examination of numbers of these specimens indicated that they also carried consistent ring growth patterns, which could be cross-dated to form floating chronologies. The ensuing search for specimens which would bridge the gaps and so produce one long chronology is a saga of exceptionally fascinating interest.

Suffice it for our present purpose only to report that a continuous tree-ring sequence is now available for the Southwest from A. D. 11 to the present. This span covers all major periods of well represented culture stages of the prehistoric inhabitants of this area, and has made it possible to speak of events in past time in terms of years in our own calendar. The most immediate and obvious result of this dating was that almost every previous estimate of archeological dates had to be revised downwards, or shortened, in some cases radically. Here then, is evidence that culture changes more rapidly than might be expected.

Many of you will be interested to learn that the Tree Ring Laboratory at the University of Chicago has, within the past few months, released dates on Kincaid, an archeological site in southern Illinois, which fall within the 16th century A.D.[2] Archeologists are already busily engaged in interpreting these dates in terms of other sites from which

[2] Paper read by Robert E. Bell at the December 1946 Meeting of the American Anthropological Association, and affiliated societies, Chicago, Illinois.

trade material came to Kincaid, and in estimating expanded dating. For example, it has been suggested that the Middle Mississippi occupation at Kincaid probably began about A. D. 1450 and lasted to about A. D. 1630. Through the identification of trade objects the famous Cahokia Mounds may be dated as of a somewhat similar span. Thus with additional tree ring research it may be safely predicted that other both earlier and later sites and cultures will soon be dated, and so may be assigned to an absolute chronology.

Before turning to a serious examination of one archeological area, two other important methods should be briefly characterized. Extensive surface survey, occasionally supplemented by small-scale excavation testing, has proved one of the most effective and productive of archeological techniques. It depends on type descriptions of various artifacts and artifact typologies, and on relative or absolute chronology. Systematic survey, and the thorough digestion of its products, will add one more most important and fundamental field of knowledge to the study; that of geographic distribution. This prepares the background for the presentation and ordering of the available data.

If any mass of raw data is to be evaluated and interpreted, it must be arranged according to some predetermined systematic pattern. Any attempt to arrange archeological material in preparation for interpretation involves what might be considered four dimensions. Traits, which are physical representations of past events, must be ordered first in some scheme which places them in a two-dimensional geographic plane, and in a third crossing temporal sequence. I have elsewhere suggested a simple physical method by which this ordering may be accomplished.[3] If several cabinets containing a series of drawers are employed, each cabinet representing a particular geographic area and each drawer a pre-determined time period, artifacts may be placed in their appropriate case and drawer. By simply pulling out all drawers of one level, and then successive levels, it is possible to demonstrate where and when a given artifact occurred, where it spread, and when it disappeared. But this is not in itself the creation of history from prehistory, for a fourth dimension must be added.

A simple definition of history has already been suggested; it now is imperative that history be further defined. One of the tenets of anthropology is that any social structure, like any physical structure, is more than a simple sum of its constituent parts. Certainly, therefore, history must be more than the simple ordering of determined traits, or events, in their proper temporal and spacial niches. It must be the interpretation of the interrelationship of these events in terms of social patterns and principles. It is the determination of the why and how, in so far as possible, of the interrelationship of events that adds zest to archeological, and in fact all anthropological studies, and will in the end result in an understanding of the dynamics of culture, or culture change, growth, and modification.

[3] McGregor, John C., "Southwestern Archaeology." John Wiley & Sons, Inc., New York, 1941, Page 55.

This is the fourth dimension just referred to.

These, briefly and somewhat schematically stated, are the aims and methods of archeology. Almost nothing has been said about techniques, for they have little bearing on the discussion to follow.

What has been, and is now being accomplished, by these means?

Prehistoric History of the Southwest

Of all the areas of the world where archeological research has been undertaken, probably our own American Southwest is the most significant. This statement is based on several facts not generally appreciated. Systematic and intensive archeological research has been energetically prosecuted there for more than six decades. The arid physical environment, combined with a physiography which has provided many natural caves and shelters attractive to man as habitations, has made possible the preservation of articles which otherwise would have deteriorated. The arid environment has also tied man closer to the soil than in many other areas in the world, and has called forth ingenuity in the adaptation of life to a variety of physical and ecological environments. Thus a number of somewhat diversified evolutionary lines are represented.

Of more importance is the fact that here is found a social evolution which spans all stages, without break, from an exceedingly simple semisedentary-seminomadic way of life, to the highly compact, wholly sedentary stage represented today by the living Pueblo groups. As descendents of their prehistoric ancestors in the same area, these latter people supply much of the information, which through analogy, makes possible interpretation and comprehension of events indicated by artifacts in prehistoric horizons. There is also the unique contribution of tree-ring dating, already mentioned which has made possible the specific dating of all major stages in the unfolding of Southwestern cultures.

It is these reasons, plus the fact that I am most familiar with the achievements of this area, that prompt me to turn to this field as a source of material to illustrate this discussion. As a logical beginning the following simple summary of Southwestern history is offered.[4]

The earliest known evidence of man in the Southwest consists of stone artifacts which through various geological and paleontological processes have been correlated with now extinct mammals, and dated as on the order of some fifteen thousand years old. The famous Folsom Culture is probably the best known of these early finds. Unfortunately this and other related finds of somewhat comparable age lack any human remains, and they consist of such an impoverished trait complex that little is known concerning them, beyond a few tools, and the fact that the people appear to have been purely nomadic hunters.

The first more completely represented culture is the Cochise, known from southeastern Arizona. Stone work was expanded by these people to include what is probably the earliest use of grinding stones by

[4] In a paper such as this, questions still somewhat controversial must be treated as though settled.

any group in America, perhaps in the world, for they have been dated by Antevs as of about ten thousand years old. These people lived in the pluvial, or immediately postglacial period, and their remains are commonly found as camps on the borders of long since dry lakes. Two human skeletons, probably assignable to this period, have been found, but have not as yet been studied and reported.

None of these early cultures is sufficiently rich to make possible much in the way of interpretation, but by the time of Christ other people living in the southern portion of Arizona and New Mexico were well established, and are more fully represented and known. These have been designated as the Mogollones, and at this early period they had pottery, had built more or less permanent homes, practiced an economy divided between hunting, gathering, and a simple agriculture, and were individuals of some consequence.

At about this same time another related group invaded the desert country of southern Arizona to establish a long dynasty of rich cultural development. These people are known as the Hohokam. They were sedentary individuals with permanent homes, pottery, a more or less specialized stone industry, and were faced with the necessity of adaptation to a decidedly inhospitable environment. Because of the exceeding aridity of this region they settled along the permanent streams and in the foothills of the isolated mountain ranges where water was assured.

Slightly later, probably in the third or fourth century A. D., the Basket Makers settled in the northern portion of Arizona and southern Utah. They were seminomadic, practiced only simple agriculture, and relied for subsistence on gathering and hunting. Because of their way of life they constructed no permanent homes in the early portion of their reign, and lacking pottery they turned their interests and energies to the production of containers and objects of soft materials, such as fibers, in which they excelled for their time.

With these three groups accounted for we have the basis of what has commonly been accepted as the three roots, or fundamental cultures, of the Southwest. From them, as the centuries gradually unrolled, and perhaps stimulated by occasional outside influence, all of the later cultures sprang. Perhaps these three roots should even be reduced to two by combining Mogollon and Hohokam as two stems under one root, the Cochise.

By A. D. 700, the three same groups were still represented in the Southwest, although a fourth, the Patayan, may have become further differentiated, or introduced into the area along the Colorado River. Little is known about it. Mogollon was thoroughly entrenched, and although it had achieved comparatively little evolutionary progress within itself, it was exerting considerable influence on other groups, especially to the north and northwest. As they moved northward they came into contact, sometimes violently, sometimes apparently peacefully, with the resident Basket Makers, and to them contributed the bow

and arrow, at least the rudiments of pottery making techniques, and the principles of house construction. At this time the Hohokam were busily engaged in building the extensive system of canals that was to characterize their existence and make possible an expansive agriculture in the most arid portion of the Southwest. They had also established contacts with Mexico, as is testified to by shared trade, and such mutual traits as ball courts.

Three hundred years later, or by A. D. 1000, the picture had changed more or less radically. The Hohokam people had about reached their peak. They have been mentioned first because Hohokam represents an even continuation of preceding developments.

In the north the result of the Basket Maker - Mogollon contact seems to have been the development of what is known as Pueblo Culture, most spectacularly in the four corners area, where large multiroomed pueblos had been evolved, the pattern of economy firmly established as one of a highly sedentary agricultural nature, and pottery had developed to an equally rigid pattern.

On the other hand the Mogollones had suffered reverses. Apparently having shot their bolt northward to the Basket Makers they began to wane as a distinct entity, and with the southward expansion of Pueblo influence more and more took on a Pueblo cast. The general economy was also shifting from a hunting to a more sedentary type.

During the fourteenth century many radical changes took place in the Southwest, probably the most striking of which is directly traceable to the great drought, a period of about twenty years at the end of the century, which tree rings have demonstrated was a time of very little rainfall. This occasioned a mass movement of Pueblo people southward and eastward, where they pressed on others, forcing them still farther south and east. At this time Pueblo Culture had reached a high level of development, and as it moved south and eastward it was modified by every local group with which it came in contact, but on the whole retained its major works of art and general culture with little change.

What remained of Mogollon was quite overshadowed by the march of Pueblo Culture. The descendants of the Mogollones were being forced into the southwestern corner of New Mexico, where they were to have one last florescence as Mimbres.

Far to the south the Hohokam were also feeling the pressure of Pueblo contact, and the most remarkable observation which may be made about them at this time is that they apparently existed peacefully, but quite independently, side by side with Pueblo culture and people. The Hohokam had definitely passed their peak, and were making no more contributions to Southwestern development, while they clung tenaciously to most of the features of their own way of life.

What became of these several groups is a matter of consuming interest to archeologists today. The remnants of the Mogollones moved first into southwestern New Mexico, and there is some evidence that they eventually migrated on into north-

ern Mexico, but what then became of them is unknown. Many of the Pueblo people remained in the north, and are represented today by their descendants in Arizona and New Mexico, but those who moved far south to mingle with the Hohokam simply seem to have disappeared. Perhaps they once more moved north when conditions there again became advantageous. Most fascinating problem is the final disposition of the Hohokam, for their ultimate fate is shrouded in the deepest mystery of all. Perhaps they moved west to the Colorado River, there to become members of the Yuman speaking groups, or remained in the Gila and Salt River valleys to be absorbed into the Pima and later arrivals into this area.

Three hundred years later, or by A. D. 1600, about the present pattern of occupation of the major Indian groups in the Southwest was at least roughly formed. The Pueblo Indians were firmly entrenched in approximately their present homes in northern Arizona and New Mexico, and there is much evidence to lead us to believe the nomadic Apache and Navaho bands had arrived, and were rapidly becoming established. Since from this time on written records supply the necessary data for historical reconstruction, this summary outline of history can be terminated at this point.

However, major outlines rest on the meticulous demonstration of innumerable bits of history. It is therefore proposed, in the remainder of this paper, to examine a few of these small historical fragments, to see how they have been arrived at, and of what they consist.

Physiographic Provinces

Some years ago it was my privilege to be briefly associated with J. W. Hoover, geographer of Tempe State College. At that time he was greatly interested in establishing Southwestern geographic provinces, and I was immediately struck by the fact that in most cases these provinces seemed to coincide with the areas of prehistoric culture as then understood. Continued research has more clearly confirmed this association.

The Southwest may be readily divided into major physical areas, with the northern and central portion composed of a high flat plateau, dissected into broad valleys by only a few streams, and with many box canyons. This is bordered on all sides, except the extreme north, by a continuous area of dissected mountain country, or on the east by mountain ranges. South and west of this band is the typical arid desert, again with only a few major streams in broad valleys, and to the east the high plains. The three roots, previously described, are assignable in broad measure to these separate regions. The Hohokam had their entire development, in fact complete existence, in the desert area. The Mogollones, except for early sporadic and late migratory movements while under pressure, were dwellers of the mountain region. The Basket Maker, and later the Pueblo development, was almost entirely confined to the plateau area, with the exception of the rather brief southward expansion already discussed.

These broad provinces are of course divisible into many regions, each with characteristic peculiari-

ties, and each with its own distinctive variant of the broader culture pattern. However, for the moment, it would be most profitable to limit our discussion to a consideration of the effect of environment on the broader groups. Probably the most clearly marked effect of environment on culture is found in the desert area and on the history of the Hohokam. With their invasion of this uninviting environment they at once committed themselves to a culture adaptation to an unusual situation. The main streams, the Gila and Salt rivers, predetermined the major pattern of their settlements, and as soon as population concentrations reached any dimensions, demanded the use of irrigation in the prosecution of agriculture. With thinly scattered populations floodwater irrigation sufficed, but as permanent populations increased irrigation was developed, until ditches supplied water to a total acreage approaching that under cultivation at the beginning of this century in the same area.

The development of such engineering projects thoroughly tied the people to the soil, rooting them in one location, so long as this method of agriculture was locally effective. As a result the development of Hohokam culture followed a long and regular path, with its inception at about the beginning of the Christian era, and reaching a peak sometime about the eleventh or twelfth centuries A. D. A gradual decline then set in, and by probably A.D. 1450 they had reached the point of extinction, or had been absorbed by other groups. This gradual development to a high level and then decline might be considered characteristic of a firmly entrenched and smugly satisfied group.

Opposed to this is the Mogollon, which was limited to the mountain section, and was, because of the opportunities offered on every side, more preoccupied with hunting as a means of subsistence than any of the later groups. This apparent restlessness and fluidity, early led these people northward to contact and influence the Basket Makers, and later made them easy prey to the solid advance of the Pueblo people and culture. With a lack of abundant natural resources to supply large concentrations of population, and their persistent adherence to an outmoded way of life, their eventual assimilation, or dispersion, was a foregone conclusion.

On the other hand the early conversion of the Basket Makers to a new mode of existence, prodded by the necessity stimulus of the encroachments of Mogollon, with the resultant population concentrations and the development of a permanent agriculture and elaborate social structure, assured their perpetuation. Here, as is always the case, the transition period, though obviously difficult, was one of great stimulation. A new sedentary way of life was substituted for an old seminomadic form, and as soon as the new pattern had been set, with for the first time security and abundance of leisure, advance was very rapid. Population increase, and social and technical stability, then led naturally to geographic expansion, with continual additional stimulus. It was, therefore, not until the arrival of overwhelming ag-

gressive foreign European elements that Pueblo culture was forced to retreat, consolidate, isolate, and in at least some characteristics stagnate.

Cross-Dating Sites

Much more, and in many cases in great detail, could be said on this line, and shortly one or two other examples of social processes will be considered more microscopically, but just now it becomes necessary to examine another technique. Continued reference has been made to dates, yet it is a matter of general knowledge that tree ring dates in the Southwest are largely confined to the Plateau area, and there to the more datable kinds of conifers. Also, the earliest date so far secured in association with human culture stages is an early Basket Maker beam, found in Dupont Cave in Nevada, and dated as A. D. 217. How then may dates be assigned to the Hohokam stages, particularly in their earlier portions at about the beginning of the Christian era?

The most intensive work of dating, and correlation of dates with culture stages, has been that done by the Museum of Northern Arizona in the general vicinity of Flagstaff. Here it is demonstrated that the average rate of human cultural evolution resulted in distinguishable differences about every two hundred years. Once datings had been established for local groups it was then possible, by an involved process which I have referred to as "seriation," and through the establishment of cross finds, to date sites and cultures where no tree ring dates were available. For this cross-dating it was early recognized that pottery was of the utmost aid, in that once made it was practically indestructible, was on the whole abundant, was subject to continual fad changes, and might be easily collected, stored, and studied. It is by these means—cross-dating through trade pottery, and projection of dates according to what appears to be an established pattern rate of development—that dates have been assigned with some evidential basis to early periods, and also to sites without the tree ring area.

Culture Evolution Cycles

However, one of the most obvious results of this study of Southwestern archeology is that the development and change of human culture is not unilateral, and over long periods is not uniformly continuous. Rather, the history of one culture is that it tends comparatively to fluctuate with various periods of rise and regression, though in every case to gradually rise to a peak, and then more or less gradually decline. The problem now is to attempt to determine, in a few selected cases, why such a pattern forms.

Perhaps one of the most common causes of decline is the failure of individuals, and society, to readjust to changing environmental conditions. Halseth, and others, working on the problem of Hohokam decline have suggested it is associated with the difficulties which developed in their irrigation projects. He has suggested specifically that continued spreading of water over the land waterlogged it. The evaporation of quantities of water from the soil, in the arid atmosphere, led to the deposition of a layer of lime, known locally as caliche, anywhere from a foot to two or three feet below the

surface. When this had formed a seal beneath the soil, water could no longer penetrate beyond this seal but rapidly evaporated, thus rendering the lands useless to further agriculture. This is a problem still confronting irrigation farmers in this same area. Such an explanation in conjunction with theories of invasion, which are based on convincing evidence, and perhaps several cycles of continued stream erosion as a result of serious droughts, which made necessary the repeated removal upstream of canal inlets, may be the answer of the tip of balance from progression to regression.

Culture Contacts

One of the most important factors contributing to the evolution of culture is contacts. This may be demonstrated in any one of a number of cases in Southwestern prehistory, is demonstrable in history throughout the world, and is in operation on a grand scale today. The effect of Basket Maker and Mogollon contact has already been pointed out and discussed. Another example, also taken from the work of the Museum of Northern Arizona, demonstrates how a natural phenomenon may cause a social upheaval.

Some years ago it was learned that sometime in the eleventh century A. D., a volcano, something like Paricutin in Mexico, erupted and covered the surface of the ground for many square miles with a layer of volcanic ash. This ash, like that at Pompeii, covered old dwellings, but soon after it had been distributed through wind action to a more even and thinner cover people began to move back into the area. Shortly the movement became almost a land rush, in which elements of all the major roots were represented; Hohokam from the south and west, Mogollon from the south and east, and Pueblo from the North. Unfortunately it was directly in the center of this horrible mixture that this museum first began serious work, and it can be imagined what a scramble of confusing problems had to be resolved before any semblance of order could be established in our data. However, it was from this amazing congenial mixture of population that almost immediately a culture of unusually rich character sprang.

An incidental practical result, of immediate application to modern practices, came from one phase of this study. In an effort to determine why the cinder covered area was so attractive to humans a study of tree growth in the cinder field was undertaken, and compared to that outside it. It was learned that the fine dark cinders formed a mulch above the clay soil, acting to conserve moisture and at the same time absorb heat; that tree species sharply dipped down into the cinder areas, in some cases a thousand feet from their normal environments; and that a cinder depth of some eight or ten inches was the optimum condition for growth. This information was passed on to the local agricultural adviser, and you can hardly imagine my surprise the next summer when I came upon luxuriant corn fields growing at seven thousand feet from extensive cinder flats, where the farmer had only to plant and reap his harvest, since cultivation was not only impractical but unnecessary.

Culture Isolation

In general the evidence from the Southwest is that at no time, and among no people, was there any extended or extensive isolation. Several excellent recent studies of prehistoric trade have shown that contacts were far flung. Many contacts were continuous over long periods. Not only was trade extensive, but physical contact, often resulting in physical and social mixtures were common. There is evidence of mutual influence between Mexico and the Hohokam. Early contacts, even the exchange of such artifacts as pots, between the Hohokam and Mogollon has been demonstrated by detailed mineralogical studies. The Mogollon and Basket Maker contact has been repeatedly stressed, as has the later Pueblo contact with Mogollon. It should also be noted that extensive studies have been made and several papers written on the important influence exerted on the Pueblo development by Hohokam, and on the later Pueblo contact with and influence on Hohokam. The important lesson to be learned here is that cultural enrichment has always resulted to one or both of the participating groups.

Another exceedingly important point affecting the development and change of culture is the need of available leisure time. When a group is continually confronted with the necessity of procuring a bare existence, cultural advance requires great individual effort. It was not until the Basket Makers became converted to a sedentary agricultural existence that they made any radically marked development, then it suddenly blossomed. Mogollon was probably limited, certainly retarded, because of persistently clinging to a hunting economy.

Economic, social, and war pressure from without a group is undoubtedly another factor strongly influencing social development. It has the effect of consolidation from within to combat the pressure from without. However, it may induce stagnation, as apparently happened when pressure of nomadic tribes historically induced the Pueblos to consolidate into a few defensible large villages. Or, under other circumstances, it may be responsible for a marked broadening of horizons, such as was the case of the Basket Makers, but this seems to be dependent upon tribal intermixture.

Just what influence on cultural change vigorous individual leadership may have is still a matter of debate. Archeology can contribute little or nothing to the question of whether the man is the result of the times or can develop the times. History and ethnology combine in two illustrations to shed some slight light on this question. Archeological research at Sikyatki, an ancient and ruined Hopi Pueblo, was followed with much interest by the first mesa Indians. One of these was a pottery maker, Nampeyo, and she was so struck with the designs of the ancient pots that she, almost alone, by copying them, inaugurated a revolution in the pottery of these people. A similar result was observed when Indians visiting the Museum of Northern Arizona were fascinated by still older pottery designs, and again introduced a revival of style among their people. But this question is dependent upon an-

other, that of the acceptance or rejection of proffered traits.

Trait Acceptance

There is much archeological and ethnological evidence that any superior trait will be readily accepted if in so doing it does not thereby disrupt other associated and integrated traits and traditions. The steel axe was readily accepted as a substitute for the stone axe, the steel knife and the copper or iron pot for the stone knife and pottery vessel, but the Christian religion was either flatly rejected or only superficially accepted. Religion has its roots deep in the total culture of the people, with ramifications in every phase of activity. Archeology, like history, gives every evidence of the reluctance of religions to change. As example the writer found an individual buried in a small pueblo just west of Flagstaff, accompanied by sufficient obviously ceremonial paraphernalia that the ceremony represented could be identified by modern Hopi Indians. He was interred sometime early in the twelfth century, so here is evidence of a religious ceremony which persisted for more than eight hundred years with little or no change. We may therefore speak with some conviction of stable and unstable institutions and practices.

Revolutions, Crises, Barriers, Frontiers

Not long ago Gordon Childe wrote a book entitled "What Happened in History,"[5] and in it suggested that the main stream of cultural history followed a pattern which might be characterized in four stages. Of more interest at the moment is his concept that these developmental stages are separated by revolutions; the first and second by what he calls the Neolithic or food-producing revolution, the second and third by the urban revolution, and the third and fourth by the industrial revolution.

This concept of revolution is closely allied, though on a grander scale, to what Colton has called a crisis,[6] To understand what he means by a crisis it is necessary to explain what he has in mind when he refers to frontiers and barriers. When foci, which are minute temporal, areal, and cultural divisions of roots, are plotted on maps for given periods, frontiers become evident. In north central Arizona in the vicinity of Flagstaff he has worked out in great detail at least seven such frontiers. All have different qualities, some being relatively stable over a period of years, while others are fluid, with one group advancing at the expense of another.

After having examined the character of all these frontiers Colton concludes that any geographical condition which makes an area unfavorable for human occupation may become a frontier, although it may be that no natural barriers are present. One such non-barrier frontier remained almost static for nearly 600 years. He visualizes a frontier as a semi-membrane, against which traits, ideas, and even people are beating like molecules in a liquid. People diffuse slowly through frontiers on trading or other excursions, whereas, as has been sug-

[5] Childe, Gordon, "What Happened in History." Penguin Books, Inc., New York, 1946.

[6] Colton, Harold S., "The Sinagua. A Summary of the Archaeology of the Region of Flagstaff, Arizona." Bull. 22, Museum of Northern Arizona. Flagstaff, Arizona, 1946. pp. 300-301.

gested, certain traits easily diffuse through these zones.

A crisis is then described as the breaking of this membrane, when both people and ideas freely flow across the frontier. Archeologically this is the most obvious type of crisis, but there surely must be many other less obvious types. Population shifts are probably only the outward evidence of the internal cause, or the true crisis. A suggestion of what a few of these causes may have been might be undertaken at this point.

If all of the tree-ring dates from the Southwest are plotted, it becomes evident that certain periods saw more construction of new dwellings, or repair of old ones, than others. Based upon what must be admitted as far from an ideal quantity of tree ring evidence it would appear that about A.D. 700, slightly past 900, about 1100 or 1130, and near 1300 are the most apparent disruptive periods. When this information is tested against the results of archeological survey, a much more complete pattern of population shifting becomes evident.

Unfortunately there is too little information available to enlarge upon his problem before about A. D. 1100, which incidentally appears to have been one of the most crucial dates of American history, but from that time on to the present it is fairly full. Considering only the area most intensively studied, that in the north central portion of Arizona, it may be seen that at about 1130 the Tsegi and Chaco canyons were abandoned, while the Wupatki, Kayenta, Hopi country, Winona and adjacent areas, were occupied. At about A. D. 1250 the Tsegi Canyon and Mesa Verde areas were reoccupied, while Wupatki, Citadel, and parts of the Hopi Country were abandoned. At about A. D. 1300 the entire San Juan, Little Colorado, and San Francisco peaks areas were abandoned, and the Hopi Country, the upper Little Colorado and the Verde Valley were intensively occupied. By A. D. 1400, or thereabouts, all of the Pueblo people had been gathered into the Hopi and Zuni villages from the Verde Valley, the Winslow area, and from the Hopi Butte country north to the Jeddito Valley.

Crises Causes

Just what the motivating causes of all these movements were it is impossible to determine at present, but some suggestions may be made. Some time ago A. E. Douglass personally outlined to me what he called the human cycle of site occupation. It was not new with him, but I have never been able to trace it to its proper source. This theory consists of the knowledge that new occupants in a virgin area will invariably choose a spot of precarious natural balance. This is usually at the edge of a forest, to supply construction and fuel, and an open or grassland area, to make possible agriculture. Occupation of the site, with the attendant stripping off of the cover, disturbs this balance, with the result that erosion sets in, the water table lowers, occupation becomes impossible, and the people move. When nature has once more re-created a balance the same region may, and often is, once more occupied.

There is much actual evidence, in cutting and filling of wash beds in canyons, that this is exactly what happened in the very areas which have just been characterized. Certainly such a cycle is demonstrated in the Tsegi Canyon system, the Chaco Canyon, and in parts of the Little Colorado Valley. However, humans are loath to make any change, and will usually resist it to the last possible moment. What is the actual trigger event that casts the last die is more difficult of determination. It may be a drought, or continued droughts, such as is known to have taken place in the late fourteenth century. It may be a cinder fall, such as that described for the Flagstaff area, which inaugurated widespread movements of people. Or it may be even so simple a matter as the interpretation of a dream on the part of one individual in a position of great influence.

So many more ideas of such fascinating possibility have sprung from the recent study of Southwestern archeology that I should like to be able to continue with a discussion of them, but this is impossible now. By way of conclusion it might be profitable to briefly review the several points covered, and to summarize them. For convenience they are listed in order as discussed.

Summary

1. Social development, when sufficient data are available, is found to have made strides more rapid than is generally otherwise believed to have been true, at least once a certain minimum level is attained.

2. Culture units tend to be confined to certain physiographic or environmental areas.

3. In turn physiographic and ecological environments by their nature tend to restrict or to encourage the advance of culture.

4. The evolution of culture is not lineal but fluctuating, although on the whole gradually rising to a peak, after which, in all specific cases, decline sets in.

5. Cultural decline is commonly traceable to the failure of individuals and society to readjust to changing environmental conditions.

6. Cultural evolution is greatly stimulated by contacts; the closer the contact, on the whole, the more rapid the advance, and cultural enrichment often results to both participating groups.

7. Pressure from without a group may advance cultural evolution within the group, by consolidation and pointing up purpose, but conversely it may so force a group in upon itself as to retard it.

8. Leisure time is a necessary adjunct of cultural development.

9. Cultural isolation has not existed to any extent in the past, and exists almost not at all today.

10. Vigorous individual leadership in pioneering advances may in some rare cases have influenced social development.

11. New ideas and objects, even concepts, offered a group will be readily accepted only if they are superior, or promise reward, and if they may be accepted without upsetting social integration.

12. Frontiers may or may not be determined by physical barriers.

13. Some frontiers remain stable for long periods, while others are constantly shifting.

14. Traits, ideas, and even people may slowly diffuse across frontiers, usually to the mutual benefit and stimulus of the parties involved.

15. When a natural or artificial barrier breaks down, a crisis develops at that frontier.

16. Crises may be the result of causes other than the breaking down of barriers and shifting of frontiers, for the "human occupation cycle" may also give rise to a local crisis, as may drought, or any other natural or social disruptive agency.

All of this is very well, and I believe it has given some sort of answer to the question of "so what?" raised by Kluckhohn, and quoted early in this paper, but we as individuals are concerned with the problems of the present, as well as a long time prospect of the future. Considering what is likely to result from the recent war in the immediate future there is some cause for optimism. Not only will physical science and technology advance, and be applied to problems of the convenience and productiveness of our daily lives, but the mass displacement of people throughout the world is sure to have a stimulating and advantageous effect on the development of culture. Displaced persons of superior quality will be drawn to the United States, because of our high standard of living and abundant opportunities. This will result in a great stimulus, which should mean, if the lessons of history and archeology are any indication, that we will soon lead the world in culture, as well as physical production, and in all other fields.

ARCHAEOLOGY AND ANTHROPOLOGY

CLAUDE U. STONE, *Chairman*
Peoria

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1. An Upper Mississippi House-pit from the Fisher Site: GEORGE R. HORNER, Wheaton College, Wheaton.

* 2. Hopewellian Dress and Personal Ornaments in Illinois: THORNE DEUEL, Illinois State Museum, Springfield.

* 3. A Consideration of Traits and Traditions in Archaeology: JOHN C. MCGREGOR, Illinois State Museum, Springfield.

* 4. Culture Relations at the Spiro Site, LeFlore County, Oklahoma: KENNETH G. ORR, University of Chicago, Chicago.

* 5. Paper: BYRON W. KNOBLOCK, Quincy.

6. A Seven-pound Copper Axe among 1946 Hopewell Discoveries: E. SCHOENBECK, Peoria.

7. The Succession of Woodland Horizons in the Carbondale Area: MOREAU S. MAXWELL, Logan Museum, Beloit College, Beloit, Wisconsin.

*Not published.

AN UPPER-MISSISSIPPI HOUSE-PIT FROM THE FISHER VILLAGE SITE: FURTHER EVIDENCE

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The Fisher site is located on the east bank of the Des Plaines River, which is one mile above the Kankakee River into which the Des Plaines flows, both forming the Illinois River. The Fisher site was formerly a large Indian village.

Formal archaeological work was begun by George Langford in 1906, 1927; and later work was done from 1931 to 1941 by the Illinois State Museum and the University of Chicago. Wheaton college excavated a house-pit (No. 48), located in the northwest portion of the village during June-July 1946.

Wheaton's purpose for excavating this house-pit was two-fold: (1) To contribute to the general knowledge of the site, and (2) To make further study into the sequence problem relating to Langford grit-tempered ware and Fisher shell-tempered ware.

Method

Our excavating technique was to stake the house-site area, in five-foot squares, using transit, level, and stadia rod. The base-line ran approximately north to west with the center-line extending north to east at a right angle from the center line. Digging began five feet behind the base-line (square —5R1), and the resultant trench, four feet deep, proceeded southeast on a ten-foot face, until the 25R1-25-0 squares were reached. The glaciated limestone, over which the village was built, made excavating exceedingly difficult. A similar procedure was repeated starting on the north-east line, at square 20L3-25L3. This trench continued to the southwest, on a ten-foot face, until the 20L1-25L1 squares were reached.

A field notebook record was kept of each day's proceedings, recording the bench-mark, recovered objects, and other data pertinent to excavation procedure and interpretation. Photographic records in black and white, color, and colored motion pictures were made as the excavation progressed. Recovered objects were kept in paper bags, each bag marked to represent a square. Triangulation was measured on all recovered objects. The entire house-pit was not excavated.

For those unfamiliar with the term "house-pit," we define it as a shallow foundation, 12 to 18 inches deep, made by clearing the top-soil, providing a clean level place for the floor of the dwelling. The soil from the floor was piled around the edges of the foundation, giving it an appearance of greater depth.

House-pit No. 48 was rectangular in shape and approximately 30 feet long and 25 feet wide with the long axis extending north to south. The pit revealed two house walls, one inside the other, similar in construction to house-pit No. 15, excavated by the University of Chicago and described by J. W. Griffin

(1944). The function of the double walls has not been determined. Inside the walls, on the floor of the house, were twin post-holes set at opposite angles suggesting uprights to support the roof. Other posts were recovered by the party. All were completely charred and partly disintegrated. It was not possible to take any of them out intact. The average post was five inches wide and 18 inches long. The broader butt ends showed incisions, probably made by a stone axe. Quantities of charred wood were found scattered over all of the floor. Such a large quantity may indicate that the structure was destroyed by fire. This wood has been identified as sulfur-budded or bitter-nut hickory (*Carya cordiformis*) by John Leedy of the botany department of Wheaton college. There is a modern stand of this variety of hickory about nine-tenths of a mile southeast of the village site.

There were no stone artifacts recovered except for one small triangular projectile point, fashioned from buff-colored chert, and two rejects of similar flint. A stone pestle (red granite) and mortar was found on floor level in the center of the house-pit. It seemed to have been used to break and grind flint into grit as an a-tempering for pottery, rather than to produce flour. Unusually large amounts of red and yellow hematite (ocher) covered the house floor. Its use has not been determined.

The clay industry was well represented by more than 680 pot sherds. A larger proportion of the pottery was found within the house walls, on the house floor, and in the eleven refuse pits. A smaller proportion was recovered outside of the walls. Inasmuch as the house-pits have been disturbed by cultivation and consequent erosion, no particular significance can be attached to pottery distribution except at floor level which was below the plough-line. Here, as in the pits, a careful analysis did not uncover any particular distribution pattern.

Of the total pottery—687 sherds—565 or 82 percent were plain sherds; 63 or 9 percent were decorated sherds; and 45 or 7 percent were rim sherds. Of the total sherds, 409 or 60 percent were a color which ranged from buff to orange-buff, and 270 or 39 percent were gray in color (not including the smoke stains). Both the gray and buff sherds were well mixed in both horizontal and vertical distribution. Of the non-decorative techniques, paddle-cord impression was predominant. Of the decorative techniques incision by "antler horn" was predominant with "thumb" impression following.

These decorative techniques are typical of the Upper-Mississippi pattern; for example, a thumb impression around the shoulder of the pot, or simple geometric motifs of parallel or curved lines. However there is *one* most significant exception: all of the sherds are Langford grit-temper with no known sherd containing Fisher shell-tempering. This should be noted with particular significance.

No human osseous material was recovered, although we recovered large amounts of animal and fish bones as well as clam shells. These have not been identified. None was fashioned into cultural objects. In

a brief account, the foregoing is a resumé of the type of objects recovered.

Problems

Although there are a number of problems suggested by the excavation, this paper considers only the problem of sequence based upon pottery tempering. It remains as one of the large problems at the Fisher site.

Does Langford grit-tempered precede, follow, or is it contemporary with Fisher shell-tempered ware? Or stating the problem as a cultural equation: What is the relation of Woodland culture pattern to the Upper-Mississippi culture pattern?

Discussion

Investigators George Langford and James B. Griffin, the latter basing his discussions on the notebooks of the former, established a sequence according to the levels inside of the mounds. According to them the upper level (the top of the mound) contained both shell-tempered and grit-tempered ware; below, there was shell-tempered ware but no grit-tempered ware. From their conclusions shell-tempered ware preceded grit-tempered ware at the Fisher site.

However Deuel (1940) as quoted by John Griffin (1944) felt that grit-tempered pottery preceded shell-tempered pottery, and according to John Griffin, Langford and J. B. Griffin interpreted the material incorrectly.[1]

John Griffin (1944), from a report of the pottery from house-pit 15, states: "that only Upper-Mississippi sherds were found within the house, in the wall trenches, and in the postholes." The aplastic isn't defined but we assume that the pottery of the two types is meant—shell and grit temper—and that these found together are typical "in part." House-pit 15 is quite near the West mound and is apparently contemporary with its upper level.

According to the conclusions of former archaeologists we have one of two choices in relation to house-pit 48: (1) Either the house-pit represents a pre-shell-temper or early culture manifestation; or (2) it represents a post-shell-temper or late culture manifestation.

Conclusions

Considering all of the traits diagnostic to the Upper-Mississippi pattern, evidence from the investigations of Langford and J. B. Griffin, and the added evidence of house-pit 48, it would certainly seem that shell-tempered pottery preceded grit-tempered pottery at the Fisher site. The sequence from bottom to top is:

3. grit
2. shell and grit
1. shell

This does not exclude the possibility of a very early Woodland culture, before the Mississippian, for this general area; it has not shown up yet at the Fisher site.

What can be inferred beyond this is difficult to say. House-pit 48 and the cluster of nine other house-pits seem to form a nucleus apart from the main village area built around the two large mounds according to the map published by the University of Chicago (1940) of the site. One notes that this smaller nucleus had

[1] Personal communication to the author from J. B. Griffin, 1946.

two small mounds of its own; the northwest and the north-northwest mounds. If this map is accurate (there are no recognizable traces of those mounds today), this group of house-pits apart from the main group, may well represent a later period for this part of Fisher site, with this section belonging to the Oneota aspect. However, one must be cautious in making generalities from pottery evidence alone.

A clarification of the movements of the proto-historic Woodland tribes from the East into this general area (Illinois) may help to clear some of the problems in conjunction with this site, particularly in connection with the seemingly strong late woodland culture penetration which may have caused the "Fisher people" to give up shell-tempering for grit-tempering.

Some of these problems may be solved if further excavations can be made in the "Woodland" section bordering the river area, as well as in the "historic village" section where sequence problems could be nailed down at this end of history.

None of these problems will be solved unless the archaeological work can be completed within the next five years. The present owner of the site, in line with his business —sand and gravel—will reduce this area, one of the most important sites in Northern Illinois, to a hole in the ground.

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THE SUCCESSION OF WOODLAND HORIZONS IN THE CARBONDALE AREA

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During the summers of 1938 and 1939 excavation was carried on by the Department of Anthropology of the University of Chicago at the Cove Hollow Rock Shelter in Jackson County, at the suggestion of Mr. Irvin Peithman of Carbondale.[1] At the close of the 1939 season excavations were continued on a twelve-month program until the fall of 1941 by the W.P.A. Museum Extension Project under the sponsorship of the Southern Illinois Normal University, the State Museum at Springfield, and the University of Chicago. Six village sites in Jackson and Williamson counties were excavated, and an extensive surface survey was made of these two counties. As a result of this work, evidence was found of an archaic pre-pottery culture, four stages of Woodland culture, and manifestations of the Middle Mississippi culture. This paper describes and interprets five of the six horizons thus established.

No component of the archaic pattern has been found in stratigraphic relationship with other cultures in the Carbondale region. However, a number of small open camp sites, with no depth of village debris, have yielded a distinctive complex of artifacts. This complex includes the bell-shaped pestle; nutting stones; bannerstones, or atlatl weights; caches of large, parallel-sided chert blades; long diagonal-notched projectile points; grooved axes, and possibly the hematite plummet. Typologically this complex equates with similar material found in situ and recognized as belonging to a pre-pottery horizon in the shell heaps of Indian Knoll in Kentucky, Wheeler Basin in Tennessee, and Pickwick Basin in Alabama.[2] More recently artifacts belonging to this complex have been found in Massac County at the Faulkner Site.[3] Here a hunting and gathering group, using no pottery and hunting primarily with the atlatl and spear, definitely preceded the first pottery using group of the Baumer Focus. There is a close similarity between artifacts of the Faulkner Focus, and the camp site materials from the vicinity of Carbondale. As additional evidence, the only portion of a grooved axe to be found in the extensive excavations around Carbondale was found in the lowest level of the Crab Orchard village, underlying the oldest pottery type in the area.

The type site for the oldest focus in which pottery was present was the first village site excavated at Crab Orchard. Here, on a small knoll approximately two hundred yards from Crab Orchard Creek was a small village originally covering roughly four hundred square feet. The village refuse, or midden, was a homogeneous black layer which extended downward from two to four feet, and which contrasted strongly with the yellow sterile clay

beneath it. Throughout the village area numerous round straight-sided pits with flat bottoms had been sunk one to two feet into the basic clay. Originally, in all probability, they were approximately three feet deep, and were utilized as storage pits. Later they apparently became receptacles for trash, many of them possibly remaining open for a number of years, from the evidence of pottery style changes represented in the refuse.

The pottery of this first Woodland complex, which has been called the Crab Orchard Focus, is rather distinctive, although it demonstrates a definite generic relationship with the pottery of the Baumer Focus in Massac and Pope counties.[4] The paste is thick, rather porous, and red to reddish-brown. The tempering material is uniformly crushed rock, quartzite, or feldspar, with temper particles ranging up to six mm. in size. In the lowest levels at Crab Orchard two forms of surface treatment appear to be associated with the same ware. The first is cord roughened, with long vertical single cord impressions, applied with a cord-wrapped paddle, or possibly rolled on with a cord-wrapped dowel. This type of surface treatment was apparently of short duration, and lasted only during the beginning phases of the Crab Orchard Focus. The second surface treatment consists of impressing the surface with a small segment of woven fabric, possibly a part of a plain plaited, or plain twined wicker basket. This gives the jar the appearance of having been formed inside a basket. However, the irregularity of the impressions and the fact that some jars show a vertical warp impression on the interior of the jar, indicate that a small woven mat was used in malleating the clay. Occasionally these impressions are made in imitation of the woven fabric by the use of a cord-wrapped dowel. This ware has been called Crab Orchard Fabric Marked.

The most common pottery shape in this focus is a long, conoidal jar with a slightly constricted neck and a flattened base. This flattened base is significant in that it appears to demonstrate a cultural relationship with the flat-based fabric-marked jars found at the Ledbetter Site in west Tennessee[5] and with flat based jars from Adena Sites.[6] The earlier flat bases are hardly functional, being only two inches in diameter for jars twenty or more inches in height. Later, the flat bases were increased to an average of six inches in diameter.

The projectile points belonging to the Crab Orchard Focus are predominantly large and broad, with slightly excurvate sides, straight shoulders, and small straight or slightly expanding tangs. Although not common, the most distinctive point for this period is small, with a small shallow notch, often on only one side, a straight parallel sided tang greater than half of the over-all length of the point, terminating in an excurvate base. Flake and core knives, scrapers, and chopping tools are common. A few small ovoid hoes were found, with the characteristic dirt polish on the blades. However, these were probably used to dig the numerous pits rather than in agricultural pursuits. Celts, which were rare, were short

and broad with irregularly tapering polls.

Although the stone artifacts overshadow the bone in numbers, a distinctive bone complex appears in the various components of this focus. This is significant, for due to soil conditions, no bone artifacts were recovered in the Baumer Focus to the south. Sharpened splinter awls of mammal and bird bone, and sharpened antler tines are common. Less common are deer metatarsal awls in which the joint has been utilized as a handle. Two large antler "drifts" or flaking hammers and one drilled handle were found. Although the antler projectile points actually found were rare, their relative frequency in the complex is apparent from the number of discarded antler blanks, which were cut in such a fashion that a tanged tine would be available for use as a projectile point. The four finished points which were found were uniformly long, with rather shallow sockets and triangular tangs. The sockets had been gouged out of the soft interior of the antler with a sharp tool.

As yet there has been no indication of house structure in connection with any of the Carbondale Woodland horizons. However, in the Baumer Focus, square houses were found,[7] and we may assume that semi-permanent houses were built in Crab Orchard Focus. Burials in the Crab Orchard Focus were of the bundle type, placed in irregular pits. There was evidence of the cremation of two infants in small round fire-pits.

The similarities between the Crab Orchard Focus in the first stage of its development and the Baumer Focus are quite marked. Surface treatment and vessel shape are alike, although Baumer pottery is predominantly limestone-tempered, whereas Crab Orchard is predominantly quartzite or feldspar. Projectile point types in both foci are similar. In particular one common type with weak shoulder, expanding or parallel-sided tang, and excurvate base demonstrates a link with the Adena of Kentucky.[8]

A second stage of development of the Crab Orchard Focus has been noted in a number of components along the Crab Orchard Creek. This is marked by the intrusion of Hopewell influences in the basic Crab Orchard Focus. Rim sherds of the type classified as Type 3 by Cole and Deuel[9] appear. Cut and drilled animal jaws and teeth; stone reel-shaped gorgets; round and diagonally notched projectile points; caches of ovate "hornstone" disks and fragments of unworked copper, galena and mica are found in this level. It is significant to note that Hopewell did not supplant the Crab Orchard Focus, but merely added new elements to the basic culture. Hopewell design techniques were copied in the Crab Orchard ware, and we find cross-hatching and punctating of the rim and channel collars on Crab Orchard Fabric Marked jars. Zoned decoration, trailed and fine line incising, and punctate and dentate stamping are all present.

Recently a conical mound near the Mississippi River east of Carbondale has been found to contain a Hopewell burial. Here, on the Twenhofel Site, an extended burial was found covered with a blanket of river pearls; two pairs of copper ear

spools; an ovate fluorspar gorget; armlets and wristlets of rectangular shell gorgets, and Illinois Hopewell and Crab Orchard Fabric Marked pottery. A surface survey of the adjacent village site showed a high percentage of Illinois Hopewell sherds and Crab Orchard Fabric Marked sherds.

Two interpretations of this situation can be made. Either a Hopewell group came down the Mississippi from the Illinois River center and settled on the Twenhofel Site, or the burial mound represents the ceremonial aspect of a highly influenced Crab Orchard Woodland group. Either possibility argues for the contemporaneity of Illinois Hopewell and Crab Orchard.

After the influence of Illinois Hopewell had waned, one ceramic trait, apparently introduced by the Hopewell culture, persisted in Crab Orchard pottery. This was the technique of punching a single or double row of holes parallel to the rim from the interior of the jar, producing a row of nodes around the exterior. This appears in Crab Orchard Fabric Marked and a later pottery type tentatively classified as Crab Orchard Cord Marked.

In the stratified Raymond Site, a second Woodland horizon appears in later levels above Crab Orchard material. This has been designated as the Raymond Focus. The similarity of this focus to the Lewis Focus in Massac and Pope counties is striking.[10] Both represent a meager culture with few artifacts, and in the case of the Raymond Focus, a decadence of ceramic technique.

The pottery is crude, with more or less straight sides and round bases. Occasionally the rim is punched and noded, and often the lip is notched. The vessel walls are much thinner than were those of the Crab Orchard wares, and the paste is harder. The temper appears to be equally a baked clay, or grit, with a considerable amount of sand included in the paste. The Crab Orchard pottery was formed by coiling but the Raymond pottery was made by the paddle and anvil method. The surface in every case was marked with single cords, presumably with a cord-wrapped paddle.

The predominant projectile point in this focus is a long slender point with a straight shoulder and a contracting tang. Knives are crude parallel-sided blades with a straight base. One long bar amulet, or atlatl weight, and three small ovoid celts were found. The bone complex includes only splinter awls and sharpened antler tips. No burials or houses were found which could be related to this focus.

The third Woodland group in the Carbondale area belongs to the Dillinger Focus. This manifestation, post-dating in stratified sites both Crab Orchard and Raymond, shows a strong combination of Middle Mississippi influences with an indigenous Woodland base. The contemporaneity of this focus with central and northern Illinois foci such as Maples Mills, Pere Marquette, and Jersey Bluff has been demonstrated, and the Dillinger Focus has been placed in the Tampico Phase of the Woodland Pattern.[11]

The pottery here is predominately grit-tempered and secondarily clay-grit tempered, with no sand included in the paste. The surface is cord

marked, with the impressions of tightly twisted cords running vertically to the shoulder. From the shoulder to the round base the cord impressions are checkered. The vessel forms in the Dillinger Cord Marked ware are more varied than the older Woodland forms. A large globular jar with a slightly constricted neck is the predominant shape. However, bowls and "salt pans" are frequent. A fillet is usually applied around the exterior of the rim, and the lip notched or raised to two or four lugs. Occasionally four to eight small nodes are added to the fillet at the lip in widely spaced groups. Two pottery variants are worthy of notice. The first is a small thick-walled conoidal tetrapodal vase, similar to fragments found on the surface of the village site at Cahokia in the Jersey Bluff Focus[12] and at the Pere Marquette Site.[13] The second is a small very thin-walled jar decorated with thin applied fillets which have been punctated. Other pottery artifacts were small dippers, a grit-tempered pottery trowel, an obtuse angle pipe, pottery disks, and a plummet-like object.

The stone complex also shows the weight of Mississippi influence. Although there are many of the large Woodland projectile points, the predominant form is a small unnotched, or side-notched triangle. Drills are small with expanded straight bases; flake knives are predominantly ovoid, and celts are thin, with parallel sides. Crude stone discoidals are present. In general the stone complex has been reduced in variety, and the bone complex expanded. Although splinter awls are common, the characteristic awl for the Dillinger Focus is a cut deer metatarsal, the joint serving for a handle. Bone chisels, antler punches, and bone fish hooks are common. Antler projectile points in this focus are significantly different from those found in the Crab Orchard Focus. They are much smaller, with ovate tangs, and the socket has been drilled and reamed, rather than gouged. Bone tallies cut from large bird bones are common. Tubular and flat bone beads are present but rare.

As in the earlier Woodland cultures, round flat-based pits had been dug throughout the village area. The refuse from these pits demonstrated a wide range of fauna, from the field mouse and mole to the wapiti. Occasional burned and cracked human femori indicated a possible cannibalism. Fish appeared to play a greater role in the diet of these people than of the earlier Woodland groups.

Although wattle and daub bricks were frequent in the refuse pits, there was no positive evidence of permanent houses. A survey along the Mississippi bluffs indicated that the dead of this focus were buried in slab box graves along the Mississippi. However, information regarding the burial complex must depend upon further excavation.

The exact position of the Dillinger Focus in regard to Middle Mississippi has not been determined. Ceramic traits and artifacts show a generalized Mississippi influence which cannot be related definitely to either Old Village, Trappist or Spoon River Foci. Recently Maples Mills and Old Village pottery were found in association, underlying a Spoon River component at the Gerren Site

in Fulton County.[14] This would indicate that the Dillinger Focus possibly preceeds the climax of Middle Mississippi development along the river. The Dillinger Focus may have persisted through the relatively short Middle Mississippi period. However, the absence of specialized Trappist or Spoon River traits would seem to make this questionable. Further information is needed on the ceremonial aspects of the focus. This will undoubtedly come from a more complete study of the burial complex along the Mississippi River bluffs.

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A SEVEN-POUND COPPER AXE AMONG 1946 HOPEWELL DISCOVERIES

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Four burials in a Fulton County mound, with their accompanying burial goods which include as an outstanding item, a 7-pound copper axe, are among the 1946 Hopewell discoveries of Mr. and Mrs. George Schoenbeck, members of Peoria Academy of Science, to be reported in this paper.

Other discoveries described briefly include material from three additional sites near the mound: a Hopewell village site, a Mississippi village site, and a Mississippi burial site. Recorded, also, as of interest, is another Hopewell find from the Steuben village site.

The first Fulton County discoveries were made September 22, 1946, when a fresh road-cut was investigated. The cut affected four adjacent sites, all of which had been previously recorded by Cole and Deuèl in "Rediscovering Illinois,"[1] as among the mound and village sites of the general Sister Creeks group. These sites were designated as F° 60 (unit No. 60 in the Fulton County survey), a Hopewellian Mound; F^{v} 49, a Hopewellian village termed the Whitnah village; F^{v} 47, a Mississippian village; and F° 48, a Mississippian burial place.

Hopewell Mound

First, brief exploration was done at the Hopewell mound, considered the most important site, and results suggested there should be a full investigation. A report was made to Dr. Thorne Deuel, Director of Illinois State Museum, and work was withheld. At the other sites, all with material conspicuously exposed, some work was done.

After Dr. Deuel stated the museum could not undertake exploration of the mound and after road work had again exposed and destroyed still more material, the Schoenbecks, three weeks later, made a limited excavation. A few days after the excavating, more road work destruction occurred when a signpost was placed inside the face of the mound.

The large copper axe was one of five that accompanied the three original burials in the mound. Four of them, surrounded by bark as though wrapped in it and the bark preserved by the copper, occupied the same relative position, under the base of the skull, with the small end protruding to the left of the head. The fifth one was lower, possibly by the hand of the skeleton having the big axe.

All axes are covered with verdi gris, but exposed areas on the large one show a high polish. Each was but a part of the burial goods, which included several types of shell and pearl beads, cut human and animal jaws, worked bear canines, and stone gorgets. No Hopewell pipes, mica, copper other than the axes, Hopewell flint blades, or other chert arti-

[1] Cole, Fay-Cooper, and Deuel, Thorne, Rediscovering Illinois: Univ. of Chicago, 1937.

FIG. 1.—Hopewell mound in foreground, Hopewell village at base of bluff, Mississippian sites on bluff.

facts were found, though such might have been in the destroyed areas.

Weight of the large axe is seven pounds. Measurements are: length, 12⅝ inches or 32 centimeters; width of blade, 3¼ inches or 8.1 centimeters; width of poll, 1⅛ inches or 2.8 centimeters. Thickness at center is 1 inch or 2.4 centimeters.

The other four measure and weigh as follows:

Length (in.)	Blade width (in.)	Poll width (in.)	Weight
8	3¼	2	2½ lbs.
6½	2⅝	1¼	1 lb. 1 oz.
5⅛	2	¾	14 oz.
5½	2	1 5/16	11 oz.

Only the northwest quarter of the mound remains, the rest of it having been cut away by road building. Its two sloping cut faces, each with a ditch at base, meet at approximately the mound center, where the burials lay. A low remnant of the mound showed on the far side of the new road, from the east face, but it has since been buried under a fill. The south face measures about 40 feet and the east one about 60 feet, their exact outer ends being hard to determine. The mound height is about 6 feet above the burial floor.

In the east face appeared a very definite sloping black layer, 3 to 4 inches thick, which is possibly an old sod line on the top of an original mound. It showed for a length of 9 feet; its upper end was one foot below the present top, and the other was several feet lower and disappeared over the burial area. It suggested that the top of the original mound dropped over the general burial area and that a new top had been built up later.

First burial evidence was seen at the east end of the south face as a fairly distinct, gray horizontal line or layer, 1 to 1½ inches deep, extending westward about 9 feet, which suggested and later proved to be a floor. Small fragments of bone were in the ditch.

Shallow digging revealed three skeletons on the floor, with heads to the north, approximately, and a dug-in burial at a higher level and further west, with head to the east. There were amounts of white bone ash on an inclined area to the north of the burials, and lastly two de-

posits of remains on the other sides of the two ditches, which may, or may not, have been in original position.

Two of the three skeletons on the floor lay extended, but lower parts had been cut away at about the hip line by the road machinery. The third one, which lay to the right and west of the extended ones, was flexed and had been cut through just above the ankles. The skeleton of the higher, dug-in burial was flexed and, lying in an east-west direction behind the cut face, was undisturbed.

The floor was a layer of bark. This bark mass separated and broke away freely, offering a sharp cleavage line. Soil beneath the layer was a gray-brown mottled clay, and a higher level for this clay in the area north of the burials and ash suggests the bark floor was a sunken one. Soil covering the three skeletons was a black, dense, very hard soil like a gumbo or a swamp muck, so very hard when dried by the air as to seem impenetrable. No sand floor was located.

Bones were exceedingly soft. The combined extremes of hardness of soil and softness of bones made digging most difficult and caused more or less unavoidable destruction of burial material, particularly of bones.

Particles of white ash were seen on the east face immediately north of the head of the east skeleton and shallow digging exposed several irregular layer-like deposits of this ash. The layers sloped downward to the west but how far they extended is not known. Soil lay between the ash layers. No evidence of fire on the area, i.e. no baked soil, red-burned soil, charcoal or charred bone could be seen, though bits of charcoal were in the soil further north. The ash extends eastward across the ditch and suggests there may have been more burials there.

Some grave goods, part of which were found in the first shallow exploration and part found in the ditch following additional road work, have been tentatively assigned to two burials, according to location and other considerations. It was fortunate that the first items were obtained when they were because the later ditch work removed the front area of the mound.

The skeleton having the large axe lay extended upon its back, with the other extended one to its left and the flexed one to the right. Eighty barrel-shaped shell beads were around the neck and a portion of a perforated split bear canine, notched on inner edge, lay near them. This tooth was so tightly imbedded in the soil that it was brought out inside of a chunk of soil and extricated later. White material, possibly powdered shell beads, was inside the jaws, in the mouth. A piece of red ochre, a fragment of obsidian and one incised pottery sherd were in the soil.

Five copper-stained and copper-preserved pearl beads, one a 9/16 inch hemispherical one and the other four smaller cylindrical-shaped ones, were in the soil by lower left arm. Two more of the smaller beads were found later. The 11-ounce axe provided the stain on the beads and probably on another barrel-shaped bead found in ditch. Beside the axe were two large bear canines, each with two probably decorative perforations in the front and a complete

perforation in the top, probably for suspension. Lower on the arm were two small split bear canines, with notched edges perforated at the top, and bearing eight shallow decorative perforations arranged in two horizontal rows of four each. With these smaller canines were portions of eight cut and perforated human jaws, six left ones and two right ones. Here too was a portion of a human jaw with teeth, showing no cut, and a number of loose teeth.

By the right arm were two large bear canines, cut crosswise through the middle and beveled; at this cut the nerve canal showed enlargement into a perforation.

The skelton to the left lay in a similar position, but in a slightly NW-SE direction, with face turned to the left—the upper part more than the lower—and the lower jaw split up and down, suggesting weight and pressure and probably some movement of upper face. Pelvic bones were in place and vertebrae were in alignment.

Two copper axes, 6½ and 5⅛ inches long, were under the head, the larger one lower on the skull than the other. At the throat were 394 pearl and shell beads (made from columellae of marine shells) of varying size and shape. Two large perforated bear canines were, one on each side, under the jaw. Perforations consisted of two oblique ones in the face and a lengthwise one in top. Two notched and sharpened human canines were on the chest. The mouth of this skeleton also contained the white material, probably shell.

Fragments of a reel-shaped, perforated, gray shale[2] gorget lay in the soil, low on the body and close to the cut mound face, and other fragments were in the ditch. Twenty in all, they make almost a complete specimen. With the fragments in the ditch were fragments of another perforated gorget of white limestone,[2] extremely weathered and deteriorated by ground water action.

The flexed skeleton lay on its right side, in a NE-SW direction, but with head turned slightly to the left. A wide 8-inch 2½ pound axe was under the head. A portion of a perforated cut bear jaw with six jaw teeth lay east of the body, behind the back, at shoulder level. Lower leg bones protruded from the face of the mound.

The dug-in burial lay in an E-W position at a level about fifteen inches higher than the other burials and further to the west. The upper part of skeleton lay on its back, with head bent sharply forward onto chest. The skull was intact and in fair condition, better preserved than others. Teeth were well worn down. The occipital bone bore a very pronounced protuberance. Legs were bent, with knees high up and to the right of the pelvis. The skeleton gave the appearance of having been crowded into too small a hole. Sixteen split bear canines, 3 entire and 13 broken, one cut human jaw and a number of young teeth caps were imbedded in chest.

Pottery sherds found in outer mound soil and in ditches include Woodland Plain and Woodland Cord-roughened; thin leached Plain and Cord-roughened; Havana Zoned or Alternate Area; Incised; Dentate Stamped having horizontal band with plain band at top and incising

[2] Identified by Ruth Browne, Geology Instructor, Bradley University, Peoria, Ill.

and other with horizontal oblong teeth; gritty-tempered, wide-incised body similar to C. and D.'s No. 1 type; and Sister Creek Punctate in three variations.

Each of the small compact masses of burial material across the ditches seems to be isolated and may have been deposited there in a block by grader. The south one, which included a skull, lay at a depth below that of the bark floor in mound, so that if it were a burial it would have been a subfloor burial. Upper leg bones, which may belong to extended mound burials, and other bones are now weathering out of the soil on the road edge.

Hopewell Village

The Hopewell village lying on both sides of the new road going up the bluff, and extending well up the bluff face, has a freshly scraped area on the east side. From the village have been obtained perforated clam-shell hoes; a broken clay platform pipe; a cut perforated deer-bone game bone; clam shells; deer teeth; broken birdbone awl; drumhead mouth plate; grooved sharpening stone; pitted stones; otoliths; portion of limonite spade; worked fragment of turtle carapace; points and flake knives; chert scrapers; cut, hollowed, antler tip projectile point; celt fragment and many fish and other animal bones.

Around 100 rims and 86 lower rims and decorated sherds, including 5 Mississippi rims, have been collected. Represented are Naples Dentate Stamped; Crescent Dentate Stamped; Barred Ovoid Dentate Stamped; Woodland Plain with boss; Incurved Plain with sand tempering; Alternate Area or Havana Zoned; Incised; Hopewell Rocked and punctated rim; Bar stamped; Incised; Hopewell Crosshatched Rim; Imitation Hopewell Crosshatched; Sister Creek Punctate, some with boss; Clear Lake Corded-paddle-edge Stamped, both the heavy and the thin with wide-intervaled cord-roughening; and Maples Mills, or Cord Decorated (Gooden Cord Impressed).

The Maples Mills ware shows a later Woodland occupation than the Hopewell; the Mississippi sherds and a Mississippi pit dug down through the Hopewell village show a still later occupation. It is a stratified village site, with the Hopewell the strongest occupation.

Mississippian Burial Place

At the Mississippi burial place on bluff, simple burials were exposed well down the bluff slope. There was little burial goods. Bones were in excellent condition.

Mississippian Village

Pits of the Mississippi village were found on top of burials, to the north of them and to the south. One on the lower slope of bluff, dug down through the Hopewell village, was exposed in the wall of the west road-side ditch. A Mississippian globular bowl containing black soil and many fish and other fine bones, protruded from ditch wall at a 2½ foot depth below Hopewell village floor. Two other pits show on the ditch wall.

A horizontal burnt log, which a little digging showed to extend some distance, was located in the face of a side road-cut on the bluff, at a depth of 12 to 15 inches. Sherds and a portion of a small pot, a part weath-

Fig. 2.—Front and profile view of Steuben effigy.

ered out and a part remaining, were by it.

An item of interest from a pit above burials was a cut, hollow bird-bone containing another bone as fine as a darning needle and sharply pointed. Both were broken off together at one end, possibly by road machinery.

Considerable pottery was obtained from pits on bluff top. Included was a bowl with a bottom shaped like a wooden chopping bowl, topped by a very wide, flaring rim, decorated on inside, and flaring at about a 45° angle.

Steuben Village Effigy

Another Hopewell discovery, made May 5, 1946, is a carved and incised human head effigy of argillaceous sandstone[3] from the Steuben Village site located on the Illinois River, in Steuben township, Marshall County, about 23 miles north of Peoria.

The head is skillfully, effectively done.

It is a portion of some larger object, possibly a figurine, and measures in height 22 millimeters. Details offered by the effigy include the type of features and facial contour; the shape of the head and the shaved scalp; the elaborately ornamented or highly conventionalized ear; and the indication of some accouterment breaking the line between neck and left shoulder.

The site is recorded as site 22 in the Peoria Academy of Science Survey, copies of which are also in hands of University of Chicago and the Illinois State Museum. It is a sloping gravelly floodplain, lying on west bank of Illinois River, between

[3] Identified by Harold Lucy, head of Geology department, Bradley University, Peoria, Ill.

river and high bluff. Lower area is occasionally flooded and the whole is subject to very much erosion.

Abundant material has been exposed by cultivation for many years, particularly on several gravel ridges. Artifacts were excavated from a stratum exposed in the bank of a creek at a depth of over six feet. The stratum was immediately overlain by 4 inches of gravel. A portion of a human skeleton with bones in position and other material including shells, bones, etc. was found in the bed of the creek, at a slightly deeper level, likely of the same occupation period. These finds indicate that the creek, which now runs along the south side of the recognizable village area, did not exist in this particular location at the time of this occupation. Whether this deeper occupation level shows a buried sloping surface for the village now exposed on higher ground to the north or an earlier occupation has not yet been determined. The pottery dug out is Woodland.

The head was found on the freshly cultivated surface of the field following a plowing of increased depth which brought up a correspondingly increased amount of material. Most of the material was from a previously undisturbed depth as evidenced by an abundance of rotten, quickly deteriorating bones and shells, long depleted from the usual cultivation depth. A bird, of pink chert, is another effigy from this site.

BOTANY

R. O. FREELAND, *Chairman*
Northwestern University, Evanston

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1. Virginius H. Chase, Peoria Botanist: HARRY L. SPOONER, Peoria Historical Society, Peoria.

* 2. The Conspicuous Groups of Clavarioid Fleshy Fungi: MAXWELL DOTY, Northwestern University, Evanston.

3. Some Bryophytes of Coles and Clark Counties: CHARLES B. ARZENI. Charleston.

* 4. The True Irish Shamrock: JOHN B. MURPHY, DePaul University, Chicago.

5. The Control of Weeds on a Typical Prairie Farm: MARVIN R. SIBERT, London Mills High School, London Mills.

* 6. A New Species of Oedogonium from New Zealand: L. H. TIFFANY, Northwestern University, Evanton.

7. A Method for Cytological Investigation of Algae: CARROLL J. PETERSON, North Park College, Chicago.

* 8. The Growth of Conifers on Prairie Soil: RALPH W. LORENZ and J. NELSON SPAETH, University of Illinois Agricultural Experiment Station, Urbana.

* 9. Absorption of Streptomycin through the Root System and Its Transfer to Other Organs: O. D. MORGAN and H. W. ANDERSON, University of Illinois Agricultural Experiment Station, Urbana.

*10. A Decade of Experimenting with Colchicine: O. J. EIGSTI. Northwestern University, Evanston.

*11. Chromosome Studies by the Colchicine Pollen-tube Method: O. J. EIGSTI and CAROL SILVER, Northwestern University, Evanston.

*12. Chromosomal Morphology in Polygonatum: O. J. EIGSTI and JEANNE TOMHAVE, Northwestern University, Evanston.

*13. The Late Blight Problem: G. H. BOEWE, Illinois State Natural History Survey, Urbana.

*14. Carbon Dioxide Concentrations at Near-soil Levels of the Atmosphere of Illinois Forests and Grasslands: HARRY J. FULLER, University of Illinois, Urbana.

*15. The Use of Thermocouples in Soil Temperature Studies: MAX E. BRITTON, Northwestern University, Evanston.

16. Additions to the Check List of the Vascular Plants of Sangamon County, Illinois: GEORGE D. FULLER, Illinois State Museum, Springfield. (Read by title.)

17. *Houstonia minima* in Peoria County: E. SCHOENBECK, Peoria Academy of Science, Peoria.

18. The Acanthaceae of Illinois: GLEN S. WINTERRINGER, University of Illinois, Urbana.

19. A Revised Check List of the Vascular Plants of the University of Illinois Woodlands: G. NEVILLE JONES, University of Illinois, Urbana. (Read by title.)

*Not published.

SOME BRYOPHYTES OF COLES AND CLARK COUNTIES

CHARLES B. ARZENI
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Introduction

The following list of Bryophytes was compiled over a period of two and one half years. The sandstone outcrops on the banks of the Embarrass River, Fox Ridge State Park, and the hanging bogs east of Charleston have been the chief collecting grounds in Coles County. These areas provide various types of habitat—the bog-inhabiting *Riccardia pinguis* and *Campylium stellatum* may be found only a few steps from the xeric species of *Grimmia*. Many collections were taken from the mesophytic ravines and woods which are widespread in this area. It was interesting to find that the campus of the Eastern Illinois State Teacher's College contributed 51 species of *Musci* and four Hepatics, making a total of 55 species collected. Two of the mosses collected here are newly reported for the state.

Most of my collecting in Clark County was confined to the Rocky Branch area in the southeastern part of the county. This region is especially rich in Hepatics, and the sandstone banks provide 40 of the 42 liverworts reported. Three species of *Sphagna, Jungermannia, Tricholea*, and a great number of *Musci* flourish here. The East-Central Illinois Bryophytes are probably best represented in this area.

At the 1934 Academy meeting, Miss Hague and Miss Stella Holmes (Barrick) presented a "List of the Bryophytes of Coles and Crawford Counties." Of the 31 mosses given in this list, I have not been able to collect *Climacium kindbergii* and *Amblystegiella confervoides*. I was unable to obtain packets of these. The *Brachythecium acutum* was incorrectly identified, and turned out to be *Leptodictyum riparium;* the *Mnium rostratum* (Schrad.) reported is *Mnium affine*. No species name was given for the *Polytrichum* in this check-list; however, the most common species in Coles County is *P. ohioense*.

R. H. Vaughan reported 72 mosses and 14 liverworts at the 1941 Academy meeting. This list appeared in the "Bryophytes of the Rocky Branch Region of Clark County, Illinois." I have been unable to collect *Hookeria acutifolia, Plectocolea crenuliformis, Mnium spinulosum, Brachythecium acutum, Fissidens viridulus*, and *Fissidens osmundioides*, which appeared in this list.

Of the 172 Bryophytes collected from Coles and Clark counties, 19 are newly reported for the state in this list. All the available literature on Illinois Bryophytes was referred to. Packets of these are deposited in the herbarium of the Eastern Illinois State Teacher's College, and in the author's personal collection. All the specimens have been checked by H. S. Conard, except the *Sphagna* which were checked by H. L. Blomquist.

I wish to express my thanks to H. S. Conard, H. L. Blomquist, A. J. Sharp, E. L. Stover, H. F. Thut, S. M. Hague, Mrs. F. E. Barrick, R. H.

Vaughan, E. Meadows, and the many other friends who helped me collect and packet material.

Names thus starred (*) are newly reported for Illinois in this list.

MUSCI

SPHAGNACEAE

**Sphagnum palustre* L. (Clark). Very common on moist sandstone banks beside stream.

**Sphagnum tenerum* Sull. & Lesq. (Clark). Common on the wet sandstone banks.

Sphagnum squarrosum Crome (Clark). Rare, and growing intermingled with *S. tenerum*. Reported collected in 1889 in the "Report of the Department of Natural History of Northwestern University." The only data given was that it was collected near Canton, Illinois.

TETRAPHIDACEAE

Tetraphis pellucida Hedw. (Coles, Clark).

POLYTRICHACEAE

Atrichum angustatum (Brid.) Bry. Eur. (Coles, Clark).

Atrichum undulatum (Hedw.) Beauv. (Coles, Clark).

Pogonatum pensilvanicum (Hedw.) Paris. (Coles, Clark).

Polytrichum commune Hedw. (Coles, Clark). Rare on hillsides in woods.

Polytrichum juniperinum Hedw. (Clark, Coles). Not common, on dry soil.

Polytrichum ohioense Ren. & Card. (Coles, Clark). Very common.

Polytrichum piliferum Hedw. (Clark). Rare and sterile; dry soil.

FISSIDENTACEAE

Fissidens cristatus Wils. (Clark, Coles).

Fissidens exiguus Sull. (Coles, Clark).

Fissidens minutulus Sull. (Coles, Clark).

Fissidens obtusifolius Wils. (Coles, Clark). Common on partly submerged rocks in Embarrass River. As far as I know, the only other report for this moss in the state was by Wolf in Fulton county.

Fissidens osmundiodes Hedw. (Clark). Reported by R. H. Vaughan in Clark county. I have not collected it.

Fissidens subbasilaris Hedw. (Coles, Clark).

Fissidens taxifolius Hedw. (Coles, Clark).

Fissidens viridulus (Web. & Mohr) Wahlenb. Reported for Clark county by R. H. Vaughan.

DITRICHACEAE

Ceratodon purpureus (Hedw.) Brid. (Coles, Clark).

Ditrichum pallidum (Hedw.) Hampe (Coles, Clark).

Ditrichum pusillum (Hedw.) E. G. Britton (Coles, Clark).

Pleuridium subulatum (Hedw.) Lindb. (Coles, Clark).

DICRANACEAE

Brothera Leana (Sull.) C. Mull. (Coles). Reported previously by Wolf & Hall in Fulton and Menard counties, and by Drexler in Champaign county.

Dicranella heteromalla (Hedw.) Schimp. (Coles, Clark).

Dicranella rufescens (Smith) Schimp. (Coles, Clark).

Dicranella varia (Hedw.) Schimp. (Coles, Clark).

Dicranum flagellare Hedw. (Clark. Very rare on moist soil along stream bank at Rocky Branch.

Dicranum scoparium Hedw. (Coles, Clark).

Dicranum rugosum (Hoffm.) Brid. This is *D. undulatum* (Ehrh.) Sturm. Very rare in Clark county.

LEUCOBRYACEAE

Leucobryum glaucum (Hedw.) Schimp. (Coles, Clark).

BUXBAUMIACEAE

Diphyscium foliosum (Hedw.) Mohr. (Coles, Clark).

POTTIACEAE

Barbula fallax Hedw. (Coles, Clark).

Barbula unguiculata Hedw. (Coles, Clark).

Desmatodon obtusifolius (Schwaegr.) Jur. (Coles, Clark).

Desmatodon Porteri James (Coles, Clark). Not common, on dry sandstone rocks.

Didymodon recurvirostris (Hedw.) Jennings (Coles, Clark).

Gymnostomum calcareum Nees & Hornsch. (Clark).

Tortella humilis (Hedw.) (Coles, Clark).

Tortula mucronifolia Schwaegr. (Coles, Clark).

Weisia viridula Hedw. (Coles, Clark).

GRIMMIACEAE

Grimmia apocarpa Hedw. (Coles, Clark).

**Grimmia laevigata* (Brid.) Brid. (Clark). Rare on dry sandstone banks at Rocky Branch.

Hedwigia ciliata Hedw. (Coles, Clark).

EPHEMERACEAE

Ephemerum crassinervinum (Schwaegr) C. Mull. (Coles, Clark). Common among the cattails at the edge of ponds.

**Ephemerum spinulosum* Schimp. (Coles, Clark). Common on moist soil in fields and at the edge of streams.

**Ephemerum spinulosum* var. *hystrix* (Lindb.) Grout (Coles). Not common, and growing intermingled with the previous plants.

**Ephemerum spinulosum* var. *Texanum* Grout (Coles). Rare and growing with *E. spinulosum*. Fruiting material taken from the wet mud around the campus lake, Eastern Illinois State Teacher's College.

FUNARIACEAE

Aphanorhegma serratum (Hook. & Wils.) Sull. (Coles, Clark).

Funaria hygrometrica Hedw. (Coles, Clark).

Physcomitrium turbinatum (Mx.) Brid. (Coles, Clark).

ORTHOTRICHACEAE

Drummondia prorepens (Hedw.) Jennings (Coles, Clark). On the bark of maples—not common.

Orthotrichum ohioense Sull. & Lesq. (Coles). Not common on the bark of white oak.

Orthotrichum pumilum Dicks. (Coles, Clark). Very common in both counties.

Orthotrichum strangulatum Schwaegr. (Coles, Clark). Not common on dry rocks.

TIMMIACEAE

Timmia megapolitana Hedw. (Clark). Not common.

AULACOMNIACEAE

Aulacomnium heterostichum (Hedw.) Bry. Eur. (Coles, Clark).

Aulacomnium palustre (Web. & Mohr) Schwaegr. (Clark). Rare along shaded stream banks.

BARTRAMIACEAE

Bartramia pomiformis Hedw. (Coles, Clark).

BRYACEAE

Bryum argentum (L.) Hedw. (Coles, Clark).

Bryum caespiticium (L.) Hedw. (Coles, Clark).

Bryum pendulum (Hornsch.) Schimp. (Clark). Not common on sandstone rocks.

Bryum pseudotriquetrum (Hedw.) Schwaegr. (Coles, Clark).

Leptobryum pyriforme (Hedw.) Schimp. (Coles, Clark).

Pohlia nutans (Hedw.) Lindb. (Coles, Clark).

Pohlia Wahlenbergii (Web. & Mohr) Andrews (Coles, Clark). Plants collected in Coles county producing antheridial heads.

Rhodobryum roseum (Bry. Eur.) Limpr. (Coles, Clark).

MNIACEAE

Mnium affine Bland. (Coles, Clark).

Mnium affine var. *rugicum* B & S (Coles, Clark).

Mnium cuspidatum Hedw. (Coles, Clark).

Mnium punctatum Hedw. (Coles, Clark).

Mnium serratum Brid. (Coles, Clark).

Mnium spinulosum Bry. Eur. Reported at Rocky Branch, Clark county by R. H. Vaughan. I have not collected it.

HYPNACEAE

Amblystegiella confervoides (Brid.) Loeske. Reported for Coles county by Miss Hague and Miss S. Holmes (Barrick).

Amblystegium compactum (C. Mull.) Aust. (Clark). Not common in stream bed.

Amblystegium Juratzkanum Schimp. (Clark).

Amblystegium serpens (Hedw.) Bry. Eur. (Coles, Clark).

Amblystegium varium (Hedw.) Lindb. (Coles, Clark).

Brachythecium acutum (Mitt.) Sull. Reported in Clark county by R. H. Vaughan.

Brachythecium flagellare (Hedw.) Jennings (Coles, Clark). Common on shaded banks.

Brachythecium oxycladon (Brid.) Jaeger & Sauerb. (Coles, Clark).

Brachythecium oxycladon var. *dentatum* (Lesq. & James) Grout (Clark). Common on moist soil; preferring stream banks.

Brachythecium rivulare Bry. Eur. (Clark).

Brachythecium salebrosum (Web. & Mohr) Bry. Eur. (Coles, Clark).
**Brotherella recurvans* (Mx.) Fleisch. (Coles, Clark). Not common on rotten logs at Fox Ridge State Park.
Bryhnia graminicolor (Brid.) Grout (Clark, Coles).
Calliergonella cuspidata (Brid.) Loeske (Clark, Coles). Rare in hanging bogs.
Calliergonella Schreberi (Bry. Eur.) Grout (Coles, Clark).
Campylium chrysophyllum (Brid.) Bryhn (Coles, Clark).
**Campylium chrysophyllum* var. *brevifolium* (Ren. & Card.) Grout (Clark). Common on moist banks. Leaves all swept to one side.
Campylium hispidulum (Brid.) Mitt. (Coles, Clark).
Campylium stellatum (Hedw.) Lange & C. Jens. (Coles). Rare in hanging bogs at "Foltz's".
Chamberlainia acuminata (Hedw.) Grout (Coles, Clark).
Cirriphyllum Boscii (Schwaegr.) Grout (Coles, Clark).
Climacium amercanum Brid. (Coles, Clark).
Climacium Kindbergii (Ren. & Card.) Grout. Reported by Miss S. Hague and Miss S. Holmes (Barrick) for Coles county.
Cratoneuron filicinum (Hedw.) Roth (Coles, Clark). Not common on old logs and in bogs. Bog plants without paraphyllia!
Entodon cladorrhizans (Hedw.) C. Mull. (Coles, Clark).
Endodon compressus (Hedw.) C. Muell. (Coles, Clark).
Eontodon seductrix (Hedw.) C. Muell. (Coles, Clark).
Eurhynchium hians (Hedw.) Jaeger & Sauerb. (Coles, Clark).
Eurhynchium serrulatum (Hedw.) Kindb. (Coles, Clark).
Heterophyllium Haldanianum (Grev.) Kindb. (Coles, Clark).
Homomallium adnatum (Hedw.) Broth (Coles, Clark).
Hygroamblystegium fluviatile (Hedw.) Loeske (Clark).
Hygroamblystegium irriguum (Wils.) Loeske (Coles, Clark).
Hygroamblystegium orthocladon (Beauv.) Grout (Coles, Clark).
Hypnum curvifolium Hedw. (Coles, Clark). Common at Rocky Branch.
Hypnum imponens Hedw. (Clark). Rare on moist soil.
Hypnum Patientiae Lindb. (Coles, Clark). Very common everywhere.
**Hypnum reptile* Mx. (Clark). Rare on rotten logs.
Leptodictyum riparium (Hedw.) Warnst. (Coles, Clark).
Leptodictyum riparium forma *flaccidum* (L & J) (Coles). Growing submerged; capsules taken in January.
Leptodictyum trichopodium (Schultz) Warnst. (Coles, Clark).
Plagiothecium denticulatum (Hedw.) Bry. Eur. (Clark).
Plagiothecium geophilum (Aust.) Grout (Clark). Not common on the moist soil along stream.
Plagiothecium Roeseanum (Hampe) Bry. Eur. (Clark). Rare at Rocky Branch.
Plagiothecium deplanatum (Sull.) Grout (Coles, Clark). Not common in crevices in the sandstone banks.
Platygyrium repens (Brid.) Bry. Eur. (Coles, Clark).
Sematophyllum carolinianum (C. Muell.) E. G. Britton (Coles, Clark). As far as I know, this is the second report for this moss in Illinois.

LESKEACEAE

Anomodon attenuatus (Hedw.) Huben. (Coles, Clark).
Anomodon minor (Beauv.) Lindb. (Coles, Clark).
Anomodon rostratus (Hedw.) Schimp. (Coles, Clark).
Leskea obscura Hedw. (Coles, Clark).
Leskea polycarpa Hedw. (Coles, Clark).
Leskea gracilescens Hedw. (Coles, Clark).
Lindbergia brachyptera var. *Austinii* (Sull.) Grout (Coles, Clark).
Thelia asprella Sull. (Coles, Clark).
**Thuidium abietinum* (Brid.) Bry. Eur. (Clark). Rare on dry soil.
Thuidium delicatulum (Hedw.) Mitt. (Coles, Clark).
Thuidium pygmaeum Bry. Eur. (Clark).
Thiudium recognitum (Hedw.) Lindb. (Coles, Clark).
Thuidium virginianum (Brid.) Lindb. (Coles, Clark).

HOOKERIACEAE

Hookeria acutifolia Hook. Reported at Rocky Branch by R. H. Vaughan.

LEUCODONTACEAE

Leptodon trichomitrion (Hedw.) Mohr (Coles, Clark).
Leucodon julaceus (Hedw.) Sull. (Coles, Clark).
**Leucodon brachypus* Brid. (Coles). Rare on bark of trees.

FABRONIACEAE

**Fabronia Ravenelli* Sull. (Coles). Not common on the bark of white oak in moist woods.

HEPATICAE

PTILIDIACEAE

Ptilidium pulcherrimum (Web.) Hampe (Coles, Clark). Not common on rotten logs along sides of ravines.

Blepharostoma trichophyllum (L.) Dumort. (Coles, Clark). Very abundant at Rocky Branch on sandstone.

**Tricholea tomentella* (Ehrh.) Dum. (Clark). Common on the moist banks along stream.

LEPIDOZIACEAE

**Bazzania trilobata* (L.) S. F. Gray (Clark). Very rare on the sandstone banks.

**Lepidozia reptans* (L.) Dumort. (Clark). Rare on rotten logs.

CALYPOGEIACEAE

Calypogeia Trichomanis (L.) Corda (Coles, Clark).

CEPHALOZIACEAE

Cephalozia connivens (Dicks.) Lindb. (Coles, Clark). Common on moist, rotten logs.

Cephalozia media Lindb. (Clark). Common on shaded sandstone.

Nowellia curvifolia (Dicks.) Mitt. Rare on rotten wood at Rocky Branch.

HARPANTHACEAE

Lophocolea heterophylla (Schrad.) Dumort. (Coles, Clark).

Lophocolea minor (Lehm.) Nees (Clark). Rare on soil and old wood.

Harpanthus scutatus (Web. & Mohr) Spruce (Clark). Not common, and growing intermingled with *Cephalozia media* and *Blepharostoma trichophyllum*.

JUNGERMANNIACEAE

**Lophozia incisa* (Schrad.) Dum. D'Obs. (Clark). Common on the moist sandstone banks, and growing with *Plectocolea*.

Jungermannia lanceolata L. (Coles, Clark). Not common, and growing among the *Sphagna*.

**Plectocolea crenulata* (Smith) Evans (Clark). Not common on the moist soil on sandstone banks.

**Plectocolea crenuliformis* (Aust.) Mitt. Reported at Rocky Branch by R. H. Vaughan.

Plectocolea hyalina (Lyell) Mitt. (Clark). Not common.

Plectocolea fossombronioides (Aust.) Mitt. As far as I know, this is the second report for the state. Not common at Rocky Branch.

PLAGIOCHILACEAE

Plagiochila asplenioides (L.) Dumort. (Clark, Coles).

SCAPANIACEAE

Scapania nemorosa (L.) Dumort. (Clark, Coles).

PORELLACEAE

Porella platyphylloidea (Schwein.) Lindb. (Clark, Coles).

RADULACEAE

Radula complanata (L.) Dumort. (Coles, Clark). Not common at the base of trees.

FRULLANIACEAE

Frullania Asagrayana Mont. (Coles). Rare on the bark of white oak.

Frullania eboracensis Gottsche. (Coles, Clark).

Frullania inflata Gottsche. (Coles, Clark).

Frullania riparia Hampe (Coles, Clark). Common on moist sandstone.

Frullania squarrosa (R. Bl. & N.) Dumort. (Clark). On shaded banks; preferring moist sandstone. Common.

LEJEUNEACEAE

**Lejeunea cavifolia* (Ehrh.) Lindb. (Clark). Rare on rotten wood.

PELLIACEAE

Pellia epiphylla (L.) Corda (Coles, Clark). Very common on moist soil and rocks.

BLASIACEAE

Blasia pusilla L. (Clark). Very common on sandy soil.

RICCARDIACEAE

Riccardia pinguis (L.) S. F. Gray (Coles). Not common among the cattails in hanging bogs.

MARCHANTIACEAE

Marchantia polymorpha L. (Coles, Clark).

Preissia quadrata (Scop.) Nees (Clark). Not common on sandstone rocks.

Conocephalum conicum (L.) Dumort. (Coles, Clark).

REBOULIACEAE

Reboulia hemisphaerica (L.) Raddi (Coles, Clark).

Mannia fragrans (Balb.) Frye & Clark (Clark). Common at Rocky Branch.

Asterella tenella (L.) Beauv. (Coles, Clark). Common on dry soil.

RICCIACEAE

Riccia fluitans L. (Coles, Clark). Not common on moist soil along river bank.

Ricciocarpus natans (L.) Corda (Coles, Clark). Not common on moist soil.

ANTHOCEROTACEAE

Anthoceros laevis L. (Coles, Clark). Common on clayey soil.

**Anthoceros crispulus* (Mont.) Douin (Clark). Common on wet rocks.

Notothylas orbicularis (Schwein.) (Coles, Clark). Common on moist soil.

ADDITIONS TO THE FLORA OF SANGAMON COUNTY, ILLINOIS

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In 1943 a check list of the vascular plants of Sangamon County was published (1) in which some 870 species were named. Now it seems desirable to make certain corrections and additions to the list, especially since there appeared in 1945 a Flora of Illinois by G. Neville Jones (2). During the past five years at least 40 additional species have been collected in the county. Mrs. Lola Carter has been particularly active in this field and has added a dozen species to the Springfield area. Notable among these are the rare fern, *Woodsia obtusa*, the little rattle-box *Crotalaria sagittalis* and two rare thistles, the Hill's thistle, *Cirsium hillii* and the tall wood thistle, *Cirsium altissimum*. Members of the Nature League of Springfield have contributed several species, some of which are rather rare.

Norman Reeder, an amateur botanist and a specialist in the grass family, has revised and corrected the list of grasses and has added 20 species, some of them rare in Illinois. A similar revision of the sedge family would be desirable and it would add many species to the flora of the county.

A further study of several species has made it necessary to drop a few species and to rectify a few erroneous determinations. The present results seem to show that there are 912 known species of vascular plants growing in Sangamon County and indicate that the total flora of the county will not fall much short of a thousand species.

Polypodiaceae
Pteridium latisculum (Desv.) Hieron.
Woodsia obtusa (Spreng.) Torr.
Typhaceae
Typha angustifolia L.
Alismaceae
Sagittaria brevirostra Mack. & Bush
Gramineae
Festuca elatior L.
Festuca obtusa Spreng.
Poa chapmaniana Scribn.
Poa nemoralis L.
Poa palustris L.
Poa sylvestris Gray
Agropyron smithii Rydb.
Sphenopholis obtusata (Michx.) Scribn.
Danthonia spicata (L.) Beauv.
Agrostis hyemalis (Walt.) BSP.
Alopecurus carolinianus Walt.
Muhlenbergia schreberi Gmel.
Muhlenbergia sobolifera (Muhl.) Trin.
Sporobolus asper (Michx.) Kunth.
Sporobolus cryptandrus (Torr.) Gray
Sporobolus neglectus Nash.
Paspalum pubescens Muhl.
Panicum lanuginosum Ell.
Panicum tennesseense Ashe
Setaria verticillata (L.) Beauv.
Cenchrus pauciflorus Benth.
Andropogon virginicus L.
Sorghum halepense (L.) Pers.
Cyperaceae
Cyperus houghtonii Torr.
Araceae
Acorus calamus L.
Juncaceae
Juncus torreyi Cov.
Betulaceae
Corylus americana Walt.
Amaranthaceae
Froelichia campestris Small
Polygonaceae
Rumex obtusifolius L.
Elatinaceae
Elatina brachysperma Gray
Ranunculaceae
Ranunculus sceleratus L.
Ranunculus flabellaris Raf.

Cruciferae
Alliaria officinalis Andrez.
Rosaceae
Instead of
Geum macrophyllum read
Geum laciniatum Murr.
Leguminoseae
Crotolaria sagittalis L.
Umbelliferae
Erigenia bulbosa (Michx.) Nutt.
Primulaceae
Aster tataricus L.
Asclepiadaceae
Asclepias tuberosa L.
Convolvulaceae
Cuscuta cephalanthi Engelm.
Labiatae
Lamium purpureum L.
Scutellaria ambigua Nutt.
Compositae
Aster tataricus L.
Antennaria neglecta Greene
Carduus nutans L.
Cirsium altissimum (L.) Spreng.
Cirsium hillii (Canby) Fern.
Helianthus tuberosus L.

The following species have been reported as occurring in Sangamon County but careful search has failed to find them.

Sanicula trifoliata Bickn.
Hydrophyllum macrophyllum Nutt.
Lobelia kalmii L.
Anaphalis margaritacea Gray
Iva xanthifolia Nutt.

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2. Jones, G. Neville, Flora of Illinois: Amer. Midland Nat. Monog. No. 2: 1-317, 1945.

A REVISED CHECKLIST OF THE VASCULAR PLANTS OF THE UNIVERSITY OF ILLINOIS WOODLANDS

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It is nearly five years since the publication of the first checklist of the vascular plants of the University woodlands,[1] and copies of that list are no longer available. Therefore it seems desirable at this time to present a new and revised list.

The University of Illinois woodlands, situated a few miles northeast of Urbana, Champaign County, Illinois, consist of approximately 100 acres of natural woods, fenced and maintained by the University of Illinois as a permanent preserve of wild life for scientific purposes. This property consists of two separate areas about one mile apart, the Brownfield Woods, and the Trelease (formerly University) Woods.

The following checklist is based chiefly upon the collections of the writer during the years 1939 to 1947. The specimens upon which the records are based have been deposited in the Herbarium of the University of Illinois. A few other species not included in this list have been attributed to these woodlands, but since reports of these plants are not based upon specimens they have been left out. The present revision includes the names of the families as well as common names for most of the species. It includes 274 species in 189 genera and 76 families.

[1] Transactions of the Illinois State Academy of Science 35: 71-72 (1942).

Division I. Pteridophyta. Ferns and Fern-allies

Ophioglossaceae Presl—Adder's-tongue Family

Botrychium virginianum (L.) Sw.—Rattlesnake Fern.

Polypodiaceae R.Br.—Fern Family

Athyrium pycnocarpon (Spreng.) Tidestr.—Glade Fern

Cystopteris fragilis (L.) Bernh.—Brittle Fern

Division II. Spermatophyta. Seed Plants

Subdivision II. Angiospermae. Flowering Plants

Class I. Monocotyledoneae

Gramineae Juss.—Grass Family

Bromus tectorum L.—Cheat

Cinna arundinacea L.—Wood Reed Grass

Dactylis glomerata L.—Orchard Grass

Diarrhena americana Beauv.

Digitaria Sanguinalis (L.) Scop.—Common Crab Grass

Echinochloa crusgallii (L.) Beauv.—Barnyard Grass

Elymus villosus Muhl.—Slender Wild Rye

Eragrostis cilianensis (All.) Link—Stink Grass

Festuca obtusa Spreng.—Nodding Fescue

Glyceria striata (Lam.) Hitchc.—Meadow Grass

Hystrix patula Moench.—Bottlebrush Grass

Leersia virginica Willd.—White Grass

Muhlenbergia mexicana (L.) Trin.—Wirestem Grass

Muhlenbergia scherberi J. F. Gmel.—Nimble Will

Panicum capillare L.—Witch Grass

Panicum dichotomiflorum Michx.—Spreading Witch Grass

Phleum pratense L.—Timothy

Poa compressa L.—Canada Blue Grass

Poa pratensis L.—Kentucky Blue Grass

Poa sylvestris A. Gray—Woodland Blue Grass

Setaria lutescens (Weig.) F. T. Hubb.—Yellow Foxtail

Sporobolus heterolepis A. Gray—Sand Dropseed
Sporobolus vaginiflorus (Torr.) Wood —Sheathing Dropseed

Cyperaceae J.St.Hil.—Sedge Family
Carex albursina Sheld.
Carex blanda Dewey
Carex bromoides Schkuhr.
Carex gravida Bailey
Carex grayii Carey
Carex grisea Wahl.
Carex hirtifolia Mack.
Carex rosea Schkuhr.

Araceae Necker—Arum Family
Arisaema atrorubens (Ait.) Bl.—Jack-in-the-Pulpit. Indian Turnip
Arisaema dracontium (L.) Schott—Green Dragon. Dragonroot

Commelinaceae Reichenb.— Spiderwort Family
Tradescantia subaspera Ker—Spiderwort

Juncaceae Vent.—Rush Family
Juncus tenuis Willd.

Liliaceae Adans.—Lily Family
Allium canadense L.—Wild Garlic
Allium tricoccum Ait.—Wild Leek
Asparagus officinalis L.—Asparagus
Erythronium albidum Nutt.—White Trout-lily
Lilium michiganense Farw.—Wild Lily
Polygonatum pubescens (Willd.) Pursh. —Solomon's-seal
Smilacina racemosa (L.) Desf.—Large False Solomon's-seal
Smilacina stellata (L.) Desf.—Small False Solomon's seal
Smilax ecirrhata (Engelm.) Wats.—Upright Smilax
Smilax hispida Muhl.—Common Greenbrier
Smilax lasioneuron Hook.—Carrion Flower
Trillium gleasoni Fern.—White Trillium
Trillium recurvatum Beck—Purple Trillium
Uvularia grandiflora Sm.—Bellwort

Iridaceae Lindl.—Iris Family
Iris shrevei Small—Iris

Orchidaceae Lindl.—Orchid Family
Aplectrum hyemale (Muhl.) Torr.—Puttyroot
Orchis spectabilis L.—Showy Orchis
Triphora trianthophora (Sw.) Rydb.—Nodding Pogonia

Class II. **Dicotyledoneae** Juss.

Salicaceae Lindl.—Willow Family
Populus deltoides Marsh.—Cottonwood
Betulaceae Agardh.—Birch Family
Carpinus caroliniana Walt.—Muscle Tree
Ostrya virginiana (Mill.) K.Koch—Ironwood
Corylus americana Walt.—Hazel

Juglandaceae Lindl.—Walnut Family
Juglans cinerea L.—Butternut
Juglans nigra L.—Black Walnut
Carya cordiformis (Wang.) K.Koch—Yellowbud Hickory
Carya ovata (Mill.) K. Koch—Shagbark Hickory
Carya laciniosa (Michx.f.) Loud.—Big Shagbark Hickory

Fagaceae A.Br.—Beech Family
Quercus bicolor Willd.—Swamp White Oak
Quercus imbricaria Michx.—Shingle Oak
Quercus macrocarpa Michx.—Bur Oak
Quercus muhlenbergii Engelm.—Chinquapin Oak
Quercus rubra L.—Red Oak (*Q. borealis* Michx.f.)

Ulmaceae Mirb.—Elm Family
Celtis occidentalis L.—Hackberry
Ulmus americana L.—American Elm
Ulmus fulva Michx.—Slippery Elm

Moraceae Lindl.—Mulberry Family
Maclura pomifera (Raf.) Schneid.—Osage-orange. Hedge-apple
Morus alba L.—White Mulberry
Morus rubra L.—Red Mulberry

Cannabinaceae Lindl.—Hemp Family
Humulus americanus Nutt.—American Hop
Cannabis sativa L.—Common Hemp. Marijuana

Urticaceae Reichenb.—Nettle Family
Urtica procera Muhl.—Common Nettle
Laportea canadensis (L.) Gaud.—Wood Nettle
Parietaria pennsylvanica Muhl.—Pellitory
Pilea pumila (L.) A.Gray—Clearweed

Aristolochiaceae Blume—Birthwort Family
Asarum reflexum Bickn.—Wild Ginger

Polygonaceae Lindl.—Buckwheat Family
Polygonum pennsylvanicum L.—Smartweed
Polygonum persicaria L.—Lady's Thumb
Polygonum punctatum Ell.—Water Smartweed
Polygonum scandens L.—Climbing False-buckwheat
Polygonum virginianum L.—Virginia Knotweed

Rumex acetosella L.—Field Sorrel. Sour Dock
Rumex crispus L.—Curly Dock

Chenopodiaceae Dum.—Goosefoot Family
Chenopodium album L.—Lamb's Quarter
Chenopodium standleyanum Aellen (*C. boscianum* of auth.)

Amaranthaceae J.St.Hil.—Amaranth Family
Amaranthus retroflexus L.—Rough Pigweed

Phytolaccaceae Lindl.—Pokeweed Family
Phytolacca americana L.—Pokeweed

Portulacaceae Reichenb.—Purslane Family
Claytonia virginica L.—Spring Beauty

Caryophyllaceae Reichenb.—Pink Family
Cerastium vulgatum L.—Common Mouse-ear Chickweed
Silene antirrhina L.—Sleepy Catchfly
Silene stellata (L.) Ait.—Starry Catchfly
Stellaria media (L.)—Vill.—Common Chickweed

Annonaceae DC.—Custard-apple Family
Asimina triloba (L.) Dunal—Pawpaw

Ranunculaceae Juss.—Buttercup Family
Actaea alba (L.) Mill.—White Baneberry. Doll's Eyes
Anemone canadensis L.—Meadow Anemone
Anemone virginiana L.—Tall Anemone
Hepatica acutiloba DC.—Hepatica
Hydrastis canadensis L.—Goldenseal
Isopyrum biternatum (Raf.) T.&G.—False Rue-anemone
Ranunculus abortivus L.—Small-flowered Buttercup
Ranunculus septentrionalis Poir.—Marsh Buttercup
Thalictrum dioicum L.—Early Meadow-rue
Thalictrum revolutum DC.—Waxy Meadow-rue

Berberidaceae T.&G.—Barberry Family
Caulophyllum thalictroides (L.) Michx.—Blue Cohosh
Podophyllum peltatum L.—May-apple. Mandrake

Menispermaceae DC.—Moonseed Family
Menispermum canadense L.—Moonseed

Lauraceae Lindl.—Laurel Family
Lindera benzoin (L.) Bl.—Spice-bush

Papaveraceae B.Juss.—Poppy Family
Sanguinaria canadensis L.—Bloodroot

Fumariaceae DC.—Fumitory Family
Dicentra canadensis (Goldie) Walp.—Squirrel-corn
Dicentra cucullaria (L.) Bernh.—Dutchman's-breeches

Cruciferae B.Juss.—Mustard Family
Barbarea vulgaris R.Br.—Wintercress
Capsella bursa-pastoris (L.) Medic.—Shepherd's Purse
Cardamine bulbosa (Schreb.) BSP.—Bulbous Cress
Cardamine douglassii (Torr.) Britt.—Purple Cress
Dentaria laciniata Muhl.—Toothwort
Iodanthus pinnatifidus (Michx.) Steud.
Lepidium virginicum L.—Common Peppercress

Grossulariaceae Dum.—Gooseberry Family
Ribes americanum Mill.—American Black Currant
Ribes missouriense Nutt.—Missouri Gooseberry

Platanaceae Lindl.—Plane-tree Family
Platanus occidentalis L.—Sycamore

Rosaceae Juss.—Rose Family
Agrimonia pubescens Wallr.—Agrimony
Crataegus crusgalli L.—Cockspur Thorn
Crataegus mollis (T.&G.) Scheele
Fragaria virginiana Duch.—Wild Strawberry
Geum canadense Jacq.—White Avens
Geum vernum (Raf.) T.&G.—Spring Avens
Malus coronaria (L.) Mill.—Wild Sweet Crabapple
Malus ioensis (Wood) Britt.—Iowa Crabapple
Prunus americana Marsh.—Wild Plum
Prunus serotina Ehrh.—Wild Black Cherry
Prunus virginiana L.—Common Chokecherry
Rosa setigera Michx.—Climbing Rose
Rubus argutus Link—Tall Blackberry
Rubus occidentalis L.—Black Raspberry

Leguminosae Juss.—Pea Family
Cassia fasciculata Michx.—Partridge-pea
Cercis canadensis L.—Redbud
Desmodium glutinosum (Muhl.) Wood
Desmodium canescens (L.) DC.
Gleditsia triacanthos L.—Honey Locust
Cymnocladus dioica (L.) K.Koch— Kentucky Coffee-tree

Melilotus officinalis (L.) Lam.—Yellow Sweet Clover
Robinia pseudoacacia L.—Common Locust
Trifolium pratense L.—Red Clover
Trifolium repens L.—White Clover

Geraniaceae J.St.Hil.—Geranium Family
Geranium maculatum L.—Wild Geranium

Oxalidaceae Lindl.—Wood-sorrel Family
Oxalis stricta L.—Upright Yellow Wood-sorrel
Oxalis cymosa Small—Common Wood-sorrel

Balsaminaceae Lindl.—Jewel-weed Family
Impatiens biflora Walt.—Spotted Touch-me-not
Impatiens pallida Nutt.—Pale Touch-me-not

Euphorbiaceae J.St.Hil.—Spurge Family
Acalypha rhomboidea Raf.—Three-seeded Mercury.
Chamaesyce maculata (L.) Small—Nodding Spurge

Limnanthaceae Lindl.
Floerkia proserpinacoides Willd.—False Mermaid

Rutaceae Juss.—Rue Family
Zanthoxylum americanum Mill.—Prickly-ash

Anacardiaceae Lindl.—Sumac Family
Rhus radicans L.—Poison-ivy

Celastraceae Lindl.—Staff-tree Family
Celastrus scandens L.—Climbing Bittersweet
Eunonymus atropurpureus Jacq.—Wahoo

Hippocastanaceae T.&G.—Horse-chestnut Family
Aesculus glabra Willd.—Ohio Buck-eye

Staphyleaceae DC.—Bladdernut Family
Staphylea trifolia L.—American Bladdernut

Aceraceae Lindl.—Maple Family
Acer negundo L.—Box-elder
Acer nigrum Michx.f.—Black Maple
Acer saccharum Marsh.—Sugar Maple
Acer saccharinum L.—Silver Maple

Vitaceae Lindl.—Grape Family
Parthenocissus quinquefolia (L.) Planch.—Virginia Creeper
Vitis vulpina L.—Frost Grape

Tiliaceae Juss.—Linden Family
Tilia americana L.—American Linden. Basswood

Malvaceae Neck.—Mallow Family
Abutilon theophrasti Medic.—Butterprint. Velvet-leaf.

Violaceae DC.—Violet Family
Viola eriocarpa Schw.—Common Yellow Violet
Viola papilionacea Pursh.—Butterfly Violet
Viola sororia Willd.—Downy Blue Violet

Araliaceae Vent.—Ginseng Family
Panax quinquefolium L.—Ginseng

Onagraceae Dum.—Evening-primrose Family
Circaea latifolia Hill—Enchanter's Night Shade
Oenothera biennis L.—Common Evening-primrose

Umbelliferae B.Juss.—Parsley Family
Chaerophyllum procumbens (L.) Crantz
Cryptotaenia canadensis (L.) DC.—Honewort
Daucus carota L.—Carrot
Osmorhiza claytoni (Michx.) Clarke
Osmorhiza longistylis (Torr.) DC.
Pastinaca sativa L.—Parsnip
Sanicula canadensis L.—Snakeroot
Zizia aurea (L.) K.Koch—Meadow-parsnip

Cornaceae Link—Dogwood Family
Cornus racemosa Lam.—Gray Dogwood

Primulaceae Vent.—Primrose Family
Samolus parviflorus Raf.—Brookweed
Lysimachia ciliata L.—Fringed Loosestrife

Oleaceae Lindl.—Olive Family
Fraxinus americana L.—White Ash
Fraxinus lanceolata Borkh.—Green Ash
Fraxinus quadrangulata Michx.—Blue Ash

Convolvulaceae Vent.—Morning-glory Family
Cuscuta gronovii Willd.—Dodder
Ipomoea hederacea Jacq.—Ivy-leaved Morning-glory

Asclepiadaceae Lindl.—Milkweed Family
Asclepias syriaca L.—Common Milkweed

Polemoniaceae DC.—Phlox Family
Phlox divaricata L.—Blue Phlox

Hydrophyllaceae Lindl.—Waterleaf Family
Ellisia nyctelea L.
Hydrophyllum appendiculatum Michx.
Hydrophyllum canadense L.
Hydrophyllum virginianum L.

Boraginaceae Lindl.—Borage Family
Lappula virginiana (L.) Greene
Mertensia virginica (L.) Pers.—Bluebells

Verbenaceae J.St.Hil.—Verbena Family
Verbena urticaefolia L.—White Vervain

Labiatae B.Juss.—Mint Family
Agastache nepetoides (L.) Kuntze
Blephilia hirsuta (Pursh) Benth.
Glecoma heterophylla Waldst. & Kit.—Ground-ivy
Leonurus cardiaca L.—Motherwort
Marrubium vulgare L.—Common Horehound
Nepeta cataria L.—Catnip
Prunella vulgaris L.—Selfheal
Scutellaria lateriflora L.—Blue Skullcap
Stachys tenuifolia Willd. — Smooth Hedgenettle.
Teucrium canadense L.—Wood-sage

Solanaceae Pers.—Nightshade Family
Solanum carolinense L.—Horse-nettle
Solanum nigrum L.—Black Nightshade

Scrophulariaceae Lindl.—Figwort Family
Collinsia verna Nutt.—Blue-eyed Mary
Mimulus alatus Ait.—Monkey Flower
Scrophularia marilandica L.—Figwort
Verbascum blattaria L.—Moth Mullein
Verbascum thapsus L.—Common Mullein
Veronica arvensis L.—Corn Speedwell
Veronica peregrina L.—Purslane Speedwell
Veronicastrum virginicum (L.) Farw.—Culver-root

Bignoniaceae Pers.—Trumpet-creeper Family
Campsis radicans (L.) Seem.—Trumpet-creeper

Acanthaceae J.St.Hil.—Acanthus Family
Ruellia strepens L.—Smooth Ruellia

Plantaginaceae Lindl.—Plantain Family
Plantago lanceolata L.—Buckhorn Plantain
Plantago rugelii Dcne.—Common Plantain

Phrymaceae Schauer—Lopseed Family
Phryma leptostachya L.—Lopseed

Rubiaceae B.Juss—Madder Family
Galium aparine L.—Goose-grass
Galium concinnum T.&G.—Shining Bedstraw
Galium obtusum Bigel—Stiff Bedstraw

Caprifoliaceae Vent.—Honeysuckle Family
Sambucus canadensis L.—Common Elder
Viburnum lentago L.—Nannyberry
Viburnum prunifolium L.—Blackhaw

Campanulaceae Juss.—Bellflower Family
Campanula americana L.

Lobeliaceae Dum.—Lobelia Family
Lobelia inflata L.—Indian-tobacco
Lobelia siphilitica L.—Blue Cardinal-flower

Compositae Adans.—Composite Family
Achillea millefolium L.—Yarrow
Actinomeris alternifolia (L.) DC.—Yellow Ironweed
Ambrosia elatior L.—Common Ragweed
Ambrosia trifida L.—Giant Ragweed
Arctium minus (Hill) Bernh.—Common Burdock
Aster pantotrichus Blake—Missouri Aster
Aster pilosus Willd.—Heath Aster
Aster sagittifolius Wedem.—Arrow-leaved Aster
Aster shortii Lindl.—Short's Aster
Bidens vulgata Greene—Common Beggar-ticks
Cacalia muhlenbergii (Sch.—Bip.) Fern—Indian-plantain
Cirsium vulgare (Savi) Airy-Shaw—Bull Thistle
Cirsium arvense (L.) Scop.—Canada Thistle
Erigeron annuus (L.) Pers.—Whitetop
Erigeron canadensis L.—Horseweed
Erigeron philadelphicus L.—Philadelphia Fleabane
Eupatorium purpureum L.—Joe-pye Weed
Eupatorium rugosum Houtt.—White Snakeroot
Helianthus strumosus L.—Sunflower
Helianthus tuberosus L.
Lactuca biennis (Moench) Fern.—Tall Blue Lettuce
Lactuca canadensis L.—Wild Lettuce
Lactuca floridana (L.) Gaertn.
Lactuca scariola L.—Prickly Lettuce
Polymnia canadensis L.—Leafcup
Rudbeckia laciniata L.—Goldenglow
Rudbeckia triloba L.—Brown-eyed Susan
Solidago altissima L.—Tall Goldenrod
Solidago nemoralis Ait.—Field Goldenrod
Solidago rugosa Mill.—Rough-leaved Goldenrod
Solidago latifolia L.—Broad-leaved Goldenrod
Taraxacum officinale Weber—Common Dandelion
Taraxacum laevigatum (Willd.) DC.—Red-seeded Dandelion
Vernonia missurica Raf.—Ironweed

A METHOD FOR CYTOLOGICAL INVESTIGATION OF ALGAE

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The pollen tube technique used for cytological studies of the microgametophyte of Angiosperms was adapted for cytological and morphological studies of algae. This method mainly follows that outlined by Eigsti (1940) for the procedures used in cultivating pollen tubes and the staining and permanent mount technique used in cytological investigations (Eigsti, 1942).

The many hours and many steps necessary in present day methods have stimulated this technique for fast permanent mounts requiring a rather simple procedure. In classes studying morphology and cytology of algae, time would not allow a consideration of personal investigation by the student. It is with two objectives that this report is given. (1) To introduce a new method for detailed cytological investigation of algae on the part of experienced technicians, and (2) to point out to teachers of cytology that this method can easily be introduced as a means of personal investigation by the student.

Vigorous stocks of algae provide the best material. When nuclear phases are desired, examination at various intervals throughout a 24-hour day can be used to acquire proper stages of cells in division.

The desired quantity of the alga should be transferred to a glass slide with a minimum amount of water or fixative. Before the alga has any opportunity to dry out, a thin film of agar imbedding solution is added to the alga mount on the slide. The agar must be liquid at the time of application to the slide and all arrangement of the alga in the agar must be accomplished before the agar solidifies. Only an amount necessary to cover the alga is desired.

The imbedding solution consists of 1 gram of agar and 5 grams of sucrose completely dissolved by boiling in 100 ml of distilled water. The agar mixture is applied to the slide at a temperature of about 40° C. Any agar remaining can be sterilized and kept for subsequent use. A constant temperature water bath for the agar facilitates the operations at the time the mounts are prepared.

As soon as the agar and alga are on the slide, allow the film to dry. Drying is necessary to prevent the film from loosening from the slide as the slide is immersed in reagents used to stain and dehydrate the material. The amount of drying is best judged from experience and is dependent upon the species of alga used. Certain gelatinous forms can withstand drying for several hours. As a general rule, however, the drying process is accomplished within 10 or 15 minutes.

The staining series is made up as follows:

1. *Aceto-carmine*

The aceto-carmine stain is made by reflux condensing for 5 hours at a slow rate one teaspoon of carmine to 100 cc of 45% acetic acid. It is

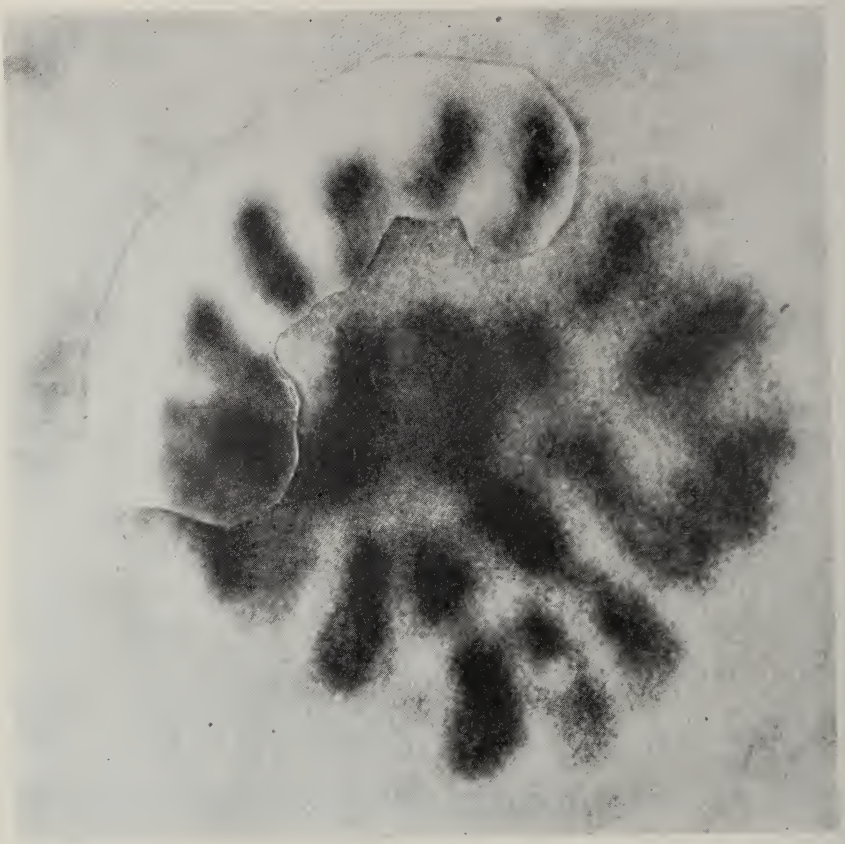

Fig. 1.—Composite photomicrograph of two focal planes of a nuclear division figure of *Rhizoclonium* X8700.

recommended that a minimum time of 20 minutes be given for this stain. The slides may remain in this stain for 24 hours without evident harmful results.

2. *45% Acetic Acid*

This is a destaining solution, and the length of time the slide is in this solution will depend on the length of time the material was in aceto-carmine. If the slide remained in the aceto-carmine for 20 minutes, it is recommended that two minutes in this solution is sufficient.

3. *Glacial Acetic Acid*

This is a destaining agent also, and the length of time the slide is in this acid will depend on the length of time the material was stained. If the slide remained in aceto-carmine 20 minutes and in the 45% acetic acid 2 minutes, one minute in this acid is sufficient. (Note: the amount of staining and destaining will necessarily vary for different types of algae.)

4. ½ *Glacial Acetic Acid* ½ *n Butyl Alcohol*

The slide should remain for 10 minutes in this solution

5. *n Butyl Alcohol*

The slide should remain for 15 minutes in this solution.

6. *Light Green in Clove Oil*

An optional counterstain for making whole mounts of algae.

7. ½ *n Butyl Alcohol* ½ *Xylol*

The slide should remain for a minimum of 10 minutes in this solution. No harmful effects are noted if the slide remains for several hours.

8. *Xylol*

Several changes of xylol are desirable.

The slides may be mounted in balsam for a permanent mount directly from the xylol.

The results from this method have been most gratifying when using plankton forms and many filamentous Chlorophyta. While experimenting with this method, species of *Rhizoclonium* and *Cladophora* were used, as the nuclei are proportionately large. After the method was mastered, the genera of *Spirogyra, Zygnema, Oedogonium, Stigeoclonium* and *Mougeotia* were tried with good results.

In *Cladophora* and *Rhizoclonium* many stages of nuclear division were observed.

In the Myxophyceae excellent results were obtained using *Oscillatoria, Lyngbya, Chroococcus, Merismopedia* and *Gloeotrichia.* Many of the diatoms were processed and excellent results were obtained.

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HOUSTONIA MINIMA IN PEORIA COUNTY

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Peoria Academy of Science

This paper reports the occurrence of *Houstonia minima* in Peoria County. This species is not listed in the Illinois State Natural History Survey's "Fieldbook of Illinois Wildflowers," published in 1936, and George Neville Jones in his "Flora of Illinois," published in 1945, cites only one instance of a collection in Knox County by Virginius H. Chase of Peoria. Britton and Brown in "Illustrated Flora of Northern United States and Canada," when giving habitat areas, mentions Illinois in parentheses followed by a question mark. The writer considers therefore that any record of its existence in Illinois should be of interest.

The species was found in full bloom, growing in thousands, on April 1, 1945, by Mr. and Mrs. George Schoenbeck, on the Edward Petty farm, located in Hollis township, section 8, on the west branch of LaMarsh Creek. This farm is twelve miles south of Peoria and about four miles west of route 24.

The plants grew in poor soil on a bald bluff overlooking LaMarsh Creek and grew so thick as to make a blue haze over the surface of the ground. The height was only 1 to 1½ inches. The area is a pasture.

The discoverey was immediately reported to Dr. John Voss, Peoria botanist and flower photographer, and director of the Peoria Academy of Science, who made photographs; and to Virginius H. Chase, director of the botany section of Peoria Academy of Science, who was furnished specimens; also to the botany section of the State Academy of Science at the May meeting. This year, 1947, it first started to bloom April 24th, flowers being very scattered among the many plants.

Upon report of the discovery, April 1, 1945, it was learned that the species had been collected in fruit by Chase on May 15, 1933, from a lowland slope one mile east of the Petty farm and east of the older Crescent Mine, a location from which it has long since disappeared, he states.

THE CONTROL OF WEEDS ON A TYPICAL PRAIRIE FARM[1]

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This paper is concerned with the control of weeds on a typical prairie farm in west central Illinois, called "Prairie Farm" in this report.

"A weed is a plant out of place." This definition includes not only the typical forms, but also those that under certain conditions are grown as valuable crops but when found with other crops are detrimental. Any plant able to grow successfully with crop plants may be looked upon as a potential weed.

Perhaps half of our most noxious weeds are those introduced from foreign countries. In Europe, for example, where the soils have been intensively cultivated for centuries, only those weeds that are extremely hardy are able to endure the conditions of cultivation and grow successfully with crops. When seeds of these crops were brought to America where large farms with much waste lands were abundant and cultivation was often less intensive, the foreign weeds accompanying the crop seeds were able to thrive.

Tehon ('37) discusses the reasons why certain weeds in Illinois are classed as pernicious and widespread control measures are needed. He states the conditions under which these weeds do the most damage, the ways in which weeds cause injury, and discusses methods used to control them. However, it is to be noted that none of the thirteen weeds listed by Tehon as the most noxious in Illinois is included in the list of the seven worst weeds on Prairie Farm.

Wilson ('44) has made an analysis of the control of noxious plants. He lists the following characteristics of weeds considered as noxious:

(a) Persistence and vigor of growth.

(b) Poisonous properties of herbage or fruits.

(c) Possession of spines or thorns injurious to animals.

Description of Prairie Farm

The farm chosen for this study consists of 161 acres of gently rolling, rich prairie land situated five miles south of Adair in Eldorado Township in west central Illinois. Most of the soil is brown silt loam with a few small areas of black silt loam. The entire farm is very fertile so that weeds as well as crops grow luxuriantly.

The present owner acquired the farm in 1941 and immediately began laying out the fields as shown in Fig. 1. There are no division fences on the south 80 acres; permanent markers on both the north and south edges divided this part into three equal fields. The other fields are di-

[1] The author wishes to acknowledge his sincere appreciation to H. D. Waggoner for help and encouragement, suggestion of the problem and for guidance in its study; to Roy M. Sallee for making the photographs; to Mary Bennett and R. M. Myers of the biology department of Western Illinois State Teachers College for aid in the preparation of the manuscript. This paper is a condensation of a thesis presented as a partial requirement for the degree of Master of Science which has been deposited in the library of the Western Illinois State Teachers College, Macomb, Illinois.

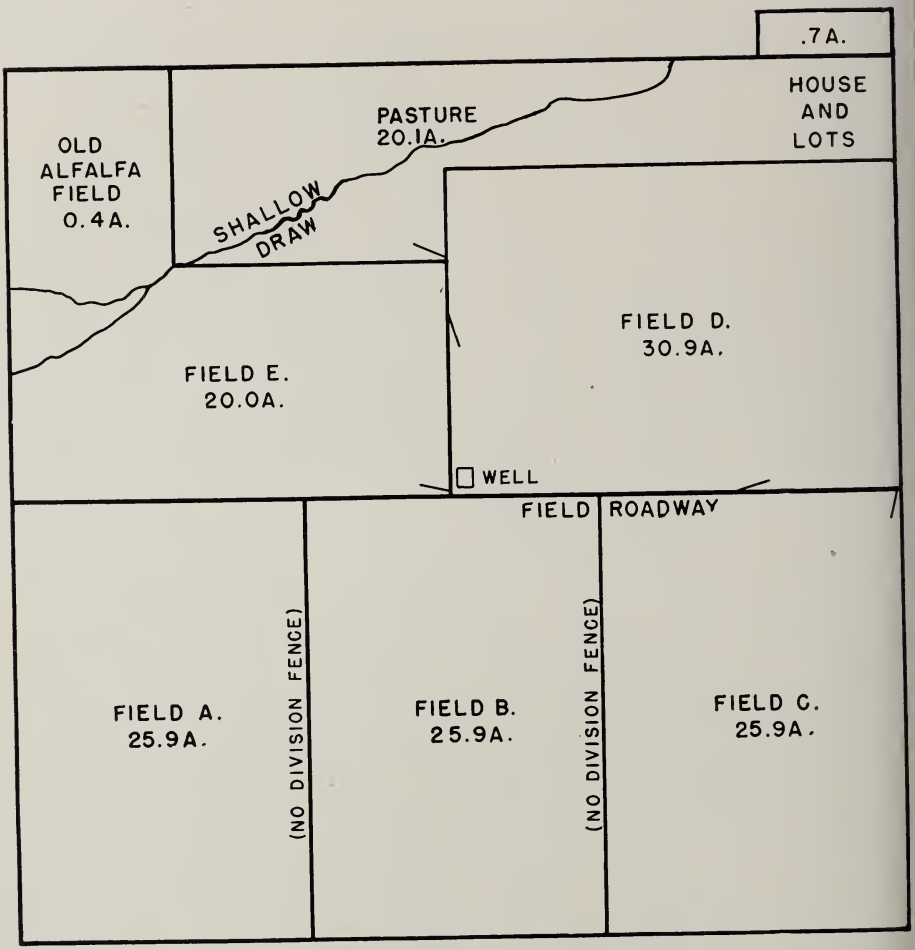

Fig. 1.—Plot plan of Prairie Farm.

vided by permanent fences with gates as shown in Fig. 1. Drainage tile run from all the low places to a ditch which passes through the northwest corner of the farm. There is a flow of water in the ditch during the entire year.

General Methods

In order to analyze the program of weed control used on Prairie Farm, approximately 150 weeds on the farm and in the general vicinity were collected, classified, and pressed for a permanent record. Frequent visits were made to the farm during the years 1943 to 1945 for observations. Conferences were held with the tenant and owner concerning procedures and results. Photographs were taken to record significant conditions and changes.

FIG. 2.—A field just across the fence from Prairie Farm. It illustrates conditions in 1941.

CHANGES BROUGHT BY THE CONTROL MEASURES USED

PRAIRIE FARM AS IT APPEARED IN 1941

When the farm was purchased there was no doubt of its fertility, but its productivity was low in everything except weeds, which were everywhere. All fields were badly infested. Weeds were along the fences, in the rows and in between the crop rows. Figure 2 illustrates the condition of some of the fields.

The seven most noxious weeds are listed in table 1.

Immediately upon acquiring the farm, the new owner began a definite system of crop rotation. This usually consisted of corn; soy beans; oats and clover. Modifications were made if clover or other crops failed. An intensive program of weed eradication and control was also started.

At all times much attention was given to clean farming. Weeds were destroyed before seeds could mature; in the corn fields with a hoe, in soy beans by pulling, and in clover and oats by cutting at harvest time.

The seven most noxious weeds (table 1) can be divided into two groups: group "A" consists of milk weed, Indian hemp and hedge bindweed. This group is difficult to control because they grow from under-

TABLE 1.—THE SEVEN MOST NOXIOUS WEEDS ON PRAIRIE FARM

Scientific Name	Common Name
**Abutilon theophrasti Medic*	Velvet Leaf
**Amaranthus retroflexus L.*	Rough Pigweed
Apocynum cannabinum L.	Indian Hemp
Asclepias syrica L.	Common Milkweed
Convolvulus sepium L.	Hedge Bindweed
**Echinochloa crusgalli (L.)* Beauv.	Barnyard Grass
Polygonum pennsylvanicum L.	Pennsylvania Smartweed

All plants were classified according to Gray('08).
*Indicates that weed is of foreign origin.

FIG. 3.—Field of soy beans in 1945. Not a weed could be found in this field.

ground parts in which considerable food is stored. Group "B" includes the remaining weeds; pigweed, Pennsylvania smartweed, velvet leaf, and barnyard grass. These weeds reproduce by seeds. It was easier to eradicate the weeds in group "B" than those in group "A", but it was more difficult to keep them under control.

The most effective method found for eradication of milkweed and Indian hemp was by pulling the plants and breaking off the stem several inches below the surface of the soil, thus preventing food storage required to promote growth the next year. The hedge bindweed was cut with a hoe for the same reason. In group "B" the weeds were cut in the blossom stage or a little later, thus preventing the maturing of seeds. This cutting had to be repeated several times each year. In addition there was careful preparation of the seed bed and cultivation of the various crops as required.

AFTER FOUR YEARS

In 1945 as a result of the program of eradication and cultivation there were few weeds on Prairie Farm, especially those having underground food storage regions. The milkweed had almost entirely disappeared. It was estimated that there was a decrease of more than 90 percent in the numbers of Indian hemp and hedge bindweed. In a field of rowed soy beans it was almost impossible to find a weed (fig. 3.) Weeds were also much reduced in the corn fields. It required considerable search to locate any hedge bindweed. In 1941 it would have been difficult to find a single corn stalk without bindweed.

It must be noted that it was necessary to continue the weed control measures. In 1945 the tenant failed to cultivate a corn field across the rows and cultivated only twice in the rows during the growing season. The result was a considerable growth of weeds in the rows of corn. These weeds probably came from seeds in the soil, as it has been shown that

weed seeds may survive for many years.

Conclusions

1. It is possible in a period of five years to eradicate or control many of the noxious weeds of a typical prairie farm in west central Illinois.

2. Control can be accomplished only by carefully planned, intensive work.

3. To maintain control of the weeds it is necessary to continue a planned type of crop rotation and cultivation because one year of poor cultivation may undo the work of several years.

4. If cultivation is to result in the destruction of weeds, it should begin sufficiently early in their development to prevent their becoming well established.

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Virginius H. Chase

VIRGINIUS H. CHASE, PEORIA BOTANIST

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Virginius Heber Chase was born January 8, 1876, at Wady Petra, Stark County, Illinois, the son of Heber and Emma Brain Chase.

He is of the eighth generation from Aquila Chase, a sailing master honored by a stone tablet in the New England Historic Genealogical Building in Boston, Massachusetts, as being the first pilot at the mouth of the Merrimac River.

Aquila Chase took up land in Hampton, New Hampshire in 1640. In studying the family tree, the only record of a member being arrested for a misdemeanor is that of Aquila himself, his wife, and her brother "for gathering pease on the first day of the week." Since this all took place in a Puritan village back in 1646, perhaps the family may be said to have outlived the disgrace.

Many in the Chase line have left honorable records. For instance, the children of Deacon Dudley Chase, who represented the fifth generation from Aquila, include a physician; a successful lawyer; a bank president; a judge of the Supreme Court of Vermont, United States Senator and a member of the Council of New Hampshire, who was the father of Lincoln's Secretary of the Treasury, Chief Justice Salmon P. Chase; and of Philander Chase, the first Episcopal Bishop of Ohio and founder of Kenyon College and later the first Bishop of Illinois and founder of Jubilee College.

While we refer to Virginius Chase as a botanist, he does not aspire to that title, but would rather be considered as of the old school of naturalists, getting his joy of life from reading the book of Nature and sharing it with his friends, as did Gilbert White of Selborne and Henry D. Thoreau of Walden, and if he has a motto, it probably is that of Thomas Paine, "The world is my country and to do good is my mission."

He would not deny it if you accused him of being a collector of the most incurable type—in fact, he would prove it to you.

His first lesson in botany came at the age of three, when he toddled out to the garden and tried to eat a pretty red pepper. Perhaps Mr. Chase is not a scientist, for scientists say nothing is ever proved by a single experiment and Chase did not repeat this one. To this day, the odor and flavor of peppers of any kind are still repulsive to him.

We find the old saying, "as the twig is bent, the tree's inclined," well exemplified in Mr. Chase's case. As a child at his grandmother's home, he was allowed to look at a large prehistoric stone axe that his grandfather had found and to handle a large pink arrowhead. Then there was a woven covered basket that a sailor, a great uncle, had brought back on his last voyage from Calcutta, India, which was filled with shells from tropic seas.

A few years later, the inspection of the collection of birds' eggs of Ernest Chamberlain at Robin's Nest

Farm, proved a greater attraction than the whole World's Fair did in 1893.

At the age of five, a few days of frantic effort covered the bottom of a cardboard box with pinned butterflies, grasshoppers and beetles. A few weeks later, pests well known to all entomologists had reduced the collection to dust and that was the end of that.

Permission to collect birds' eggs was not received until some years later, in district school days. To this day, he will tell you the greatest thrill of his whole life was when he climbed the old cottonwood tree in the south pasture and saw and collected his first set of crow's eggs.

His days in district No. 9 school are chiefly remembered by the noon trips to the forty or more acres of original prairie sod a half mile to the east, with its undulating surface, where *Cypripedium candidum* grew by hundreds, *Dodecatheon meadia* by millions and *Phlox maculata* by the acre. Across the road from this were five acres which were almost a solid growth of *Iris.* Birds' eggs were the objects of the trips, but in case he might be tardy when the one o'clock bell rang, a large bouquet or an armload of the choicest flowers were always taken back to keep the teacher in good humor, and somehow he says it always worked.

Eggs of redwing blackbirds in the *Iris* and of meadowlarks and Bob Whites in the grass were abundant. The finding of the eggs of the upland plover was a rare thrill and to find those of the kildeer a constant dare. To find the eggs of the migratory shrike was a rare treat and after being away twenty years, he was much

Virginius H. Chase
19 years of age

pleased to find a pair, probably descendants of those he had robbed years ago, were again nesting in the same clump of trees.

In going home from school, a slight detour gave a quarter of a mile of dense bottomland thicket to explore, where he found nesting black-crowned night herons and little green herons, yellow-breasted chats and the commoner species. It was mostly a thicket of *Prunus americana* and *Malus ioensis,* roofed over with *Vitis riparia.* In the openings, *Trillium recurvatum* and *Mertensia* were the most abundant of flowers.

After district school days, two winters at Princeville academy ended all formal education. Then a few weeks' instruction in tele-

graphy at Wyoming and Chase took charge of the telegraph office and railroad station at Wady Petra.

With short hours and much leisure, the boy was ready for new worlds to conquer, for the commoner birds' eggs were already in his collection and others seemed to have been beyond walking distance.

At the World's Fair of 1893, he first saw a herbarium specimen and that settled it—a herbarium was the thing he wanted and must have.

His mother's old Gray's Manual she had used at Kansas University when she studied under the famous Dr. Snow looked intriguing but seemed beyond his comprehension, and his mother appeared to have forgotten the little learned in the few weeks of school. His aunt, Agnes Chase, at that time knew no botany, but with mutual interest they tackled the problem together. The night Agnes succeeded in running down *Campanula americana* by herself, the game was on for them both, and for that matter, still is.

For the first few years, Agnes in Chicago, a proof reader on the Chicago Inter Ocean, and Virginius at Wady Petra, in the railroad station, collected at every opportunity, and by exchange of fresh material by mail, verified each other's determinations.

Mr. Chase's correspondence with Hill, Ruth, Porter, Wooten, Brainerd, Lunell, Sargent, Henderson, Wheeler, Bicknell, Beal and others, and exchanges of specimens with National Herbarium, Gray Herbarium, Missouri Botanical Garden, Gleason at the University of Illinois and others made life worth while.

Chase collected plants of *Viola* for Brainerd's garden experiments, and grafts, fresh flowers and hundreds of herbarium specimens of *Crataegus* for Sargent to use in his historic round-up of that genus. Prof. Sargent came to Wady Petra to personally see the type trees of his new species—*Crataegus peoriensis* and *Crataegus pratensis*—growing, and also trees of *Crataegus illinoensis*, which Ashe had recently described from material collected by Chase.

Opinions differ, but Chase still thinks Sargent, with his field studies, knew more about *Crataegus* than any who have come since.

An incident Chase will always remember was when he put in a good part of two days trying to run down a plant with distinctly parallel-veined leaves, as all good monocotyledonous plants are supposed to have, even to reading over the description of every species in that group, only to have to give up in despair. Months later by accident he stumbled on the name of *yuccifolium* and found his plant was an *Eryngium* placed among the *Umbelliferrae*—a booby trap others no doubt have fallen into even though they don't confess.

Mr. Chase and Frank E. McDonald, another Peoria botanist, were good friends, and after selling his herbarium to the University of Illinois, McDonald gave Chase his large herbarium case and his book of notes and plant records. After McDonald's death, Chase bought his botanical library and later Mrs. McDonald gave him the moss herbarium of 2000 specimens McDonald had made during the last years of his life.

After turning over the telegraph office to a younger brother, Chase

built a grain elevator and conducted a successful business in lumber, drain tile, coal and feed at Wady Petra for five years. Then, the rest of the family having moved to Kansas, Chase traded his interests in Wady Petra for Kansas land and in three years found himself penniless and in debt.

Then followed a year with a produce dealer and wholesale grocer at Paragould, Arkansas, then a few months with an Illinois well driller, and five years in Peoria grocery stores working ten hours a day and sixteen on Saturday.

The next 28 years were spent in the P. & P. U. railroad freight house at Peoria with practically no vacations, and during two world wars working seven days a week and nine to ten hours a day, so one may perhaps be able to forgive him if he did not get much done. He did act as president of the local Audubon Society, Boy Scout Committeeman, Boy Scout Commissioner and Examiner in Bird Study and Botany for the Boy Scouts.

In addition to his collecting in Illinois, may be mentioned some 150 species in Butler county, Kansas and 664 numbers collected in a hurried trip of only 24 days with Dr. C. D. Sneller via Bad Lands of South Dakota, Black Hills, and Yellowstone National Park to Craters of the Moon and back by way of Montana and Minnesota.

A set of the plants collected at the Craters of the Moon was mounted, labeled and presented to the superintendent of the monument as the nucleus of a herbarium to show those species growing within its boundary. Two hundred fifty specimens from this trip went to the National Herbarium and a full set to the Peoria Academy of Science.

In 1939 Mr. Chase went as botanical collector to Mexico with the second Hoogstraal scientific expedition from the University of Illinois. In spite of a wreck, which deprived the expedition of its leader and forced it to travel with no windshield and only a tarpaulin to protect the specimens, Chase managed to bring back ten sets of herbarium specimens. The first set was given to the Field Museum for identification, and Dr. Standley declared it to be the best prepared lot he had ever seen come out of Mexico. Another set was given to the Peoria Academy of Science. A set of 160 grasses was presented to the National Herbarium.

To help defray expenses of the expedition, sets were sold to Gray Herbarium, University of Michigan, Missouri Botanical Garden, Carnegie Desert Museum, U. S. Division of Plant Industry, New York Botanical Garden, and University of Illinois—in all, approximately 5000 sheets.

The finding of *Syringantha loranthoides,* a tall shrub, collected only once before since it was originally collected nearly a hundred years before; collecting *Bouteloua heterostega,* which had never before been collected on continental America, and *Paspalum malacophyllum,* which had been collected in North America but once, in Yucatan; and collecting *Muhlenbergia thurberi* for the first time in Neuvo Leon, as well as two unnamed species, was quite gratifying as that particular region

had been considered pretty well worked before.

In an old publication, "Birds," issued by Nature Study Publishing Co., Chicago, one of the first publications to use crude color photography, one may find pictured the nests of orchard oriole and rose-breasted grosbeak made from nests collected by Chase and sent to the Chicago Academy of Science while Frank Baker was curator and Woodruff, taxidermist.

Mr. Chase's first published item, "A Battle of Ants," appeared in Popular Science of December, 1897. A brief sketch of the life of Frank E. McDonald was published in Rhodora of September, 1920. Between 1923 and 1926 twenty issues of the Peoria Star contained timely column articles on nature study of local interest.

For the program of the meeting of the Illinois State Academy of Science in Peoria in 1931 he presented a sketch of the life of Dr. Frederick Brendel. Two years later, when the Peoria Academy of Science organized sections for special studies, he was placed at the head of the section on Botany and Dr. C. D. Sneller, then president, said, "Of course Chase must be custodian—he has it as an enzyme in his blood," and he has held the two appointments ever since. He also served as president of the Peoria Academy in 1937.

As publicity for the Academy, under the heading of "Nature Rambles," the Peoria Star published each Sunday between 1933 and 1936 a total of 130 articles on many lines of nature study by Chase.

Two years ago, Mr. Chase donated to the University of Illinois all duplicate herbarium specimens on hand, some 8000 sheets.

His private herbarium contains 18,240 sheets of ferns and spermatophytes of the United States, 1061 sheets of foreign plants, and 2107 packets of mosses and hepatics, a total of 21,408 specimens. Besides these, he has prepared and mounted 6571 sheets for the Peoria Academy collection.

His special interest at the present time is a seed collection put up in two-dram vials—now only in the second hundred.

His private collection of shells—marine, land, and fresh water, exceeds 200 species. Of fossils from coal vein No. 2 of the famous Mazon region he has representatives of a good portion of the known species and also a fair collection from local stripping of coal No. 5 and coal No. 6 in marine fossils.

His personally collected Indian artifacts number more than 2000.

Of new species of plants to his credit he has:

Psaronius peoriensis and *Psaronius septentrionalis,* two species of fossil fern bark of Peoria county, presumably of Permian age, described by Gillette in Botanical Gazette, Vol. 49, Sep. 1937;

Xanthium chasei, a new cockle bur from Tazewell county, Illinois, described by M. L. Fernald in Rhodora, Vol. 48, April, 1946;

Galium juniperinum, a bedstraw from Neuvo Leon, Mexico, described by P. C. Standley in Botanical Series, Field Museum of Natural History, Vol. 22, June 12, 1940;

Bouteloua chasei, a grass from Neuvo Leon, Mexico, described by

Jason Swallen in Proceedings of the Biological Society of Washington, Vol. 56, page 81, Sep. 10, 1943;

Crataegus illinoensis, a red haw from Stark County, Illinois described by W. W. Ashe in Journal of Elisha Mitchell Scientific Society, Vol. XVI, Feb. 1900;

Crataegus peoriensis, a red haw from Stark and Peoria counties, Illinois, described by C. S. Sargent in Botanical Gazette, Vol. XXXI, January, 1901;

Crataegus pratensis, another species of red haw from the same region, described by Sargent in the same issue as the preceding.

From living and herbarium material collected by Mr. Chase, two hybrid violets, *Viola pēdatifída* x *sagittáta* and *Viola pēdatifída x sororia* were described by Ezra Brainerd in Bull. Torr. Bot. Club, Vol. 40, June, 1913.

In publishing *Panicum praecocius,* Hitchcock and Chase, in Rhodora, Vol. 8, 1906, took V. H. Chase's number 649, collected at Wady Petra, Illinois, as the type specimen.

That Mr. Chase has many loyal friends is attested by the fact that at Bradley University, Peoria, will be found the name of Virginius H. Chase on the Roll of Distinction, placed "in recognition of his contributions to the study of Systematic Botany, especially with reference to the Flora of Illinois." He has also been elected a life member of the Peoria Academy of Science.

Now, having recently retired, he says at last he hopes to get started doing something!

THE ACANTHACEAE OF ILLINOIS

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This study deals with the genera and species of the Acanthaceae[1] known to occur in Illinois. It is intended to present an account of the members of this family, with a means of their identification. Attention has been given to the study of *Ruellia*, with special regard to the status of *Ruellia humilis* Nutt. and *R. ciliosa* Pursh. The data for the study of geographical distribution, and taxonomic characters of genera and species have been taken from specimens in the herbarium of the University of Illinois and that of the Illinois State Natural History Survey.

The writer wishes to express gratitude for the privilege of using facilities of the Natural History Library of the University of Illinois. Generous assistance furnished by Dr. G. N. Jones of the botany department as to bibliographical material, suggestions for style of arrangement, and taxonomic concepts involved has been valuable. Thanks are due L. R. Tehon and R. A. Evers of the Natural History Survey for making available many of the herbarium specimens used in this study.

Keys are provided for the identification of the genera and the species. The statements of geographical range have been based upon P.A. Rydberg's *Flora of the Prairies and Plains of Central North America*, (1932).

[1] Acanthaceae, a family of 175 genera and about 2000 species.

Key to the Illinois Genera

1. Corolla two-lipped, fertile stamens 2; plants growing in water or along muddy shores; leaves entire, lanceolate ..... Dianthera
1. Corolla nearly regular, fertile stamens 4; plants of drier habitat; leaves broader ..... Ruellia

Dianthera americana L. Sp. Pl. 27 (1753).

Lapham (1857) 526; Patterson (1874) 11, (1876) 28; Brendel (1887) 86; Huett (1897) 112; Pepoon (1927) 471; McDougall (1936) 315; Fuller (1943) 98; Jones (1945) 233.

Justicia americana (L.) Vahl, Symb. Bot. 2: 15 (1791).

Type locality: "Habitat in Virginia."

Range: Common along muddy shores of streams, and margins of shallow ponds and lakes from Quebec to Wisconsin and south to Kansas, Texas, and Georgia. Flowering from July to September.

Adams County: Burton Creek near the cave, 4 June 1943, R. A. Evers 1138. Waters of Camp Creek, 29 May 1932, Pepoon & Barrett 2241.

Champaign County: Wet bank along Salt Fork near Sidney, 3 October 1940, G. N. Jones 13216; 20 July 1940, G. N. Jones 12460. Urbana, 7 July 1886, Waite. In ditch, St. Joseph, 24 July 1928, McDougall 152. Sandy bottom, shallow water Middle Fork of Vermilion River, 18 October 1928, Tehon & Thompson 2246.

Coles County: Paradise Lake, in water two feet deep, 8 June 1929, D. H. Thompson 2244.

Cook County: Palos Park, 6 June 1906, H. C. Cowles.

Fayette County: Dismal Creek, northeast of Farina, 14 July 1940, Louise O'Dell 375.

Grundy County: Mazon Creek, 12 June 1932, Pepoon & Barrett 5183.

Hardin County: River strand plant on limestone boulder in Ohio River near Elizabethtown, 24 June 1931, J. Schopf 2243.

Henderson County: Oquawka, H. N. Patterson.

Jefferson County: Margin of pond, 1 June 1932, Pepoon & Barrett 5233.

Kankakee County: Kankakee River northwest of Kankakee, 3 August 1912, Sherff 1603. Sandy flats along Kankakee River, 19 June 1937, R. A. Schneider 2250.

LaSalle County: Little Vermilion River at Troy Grove, 8 September 1931, Pepoon & Foster 970.

Livingston County: Pontiac, 25 July 1944, G. D. Fuller 9146.

Macon County: Lake Decatur, upper end, 26 July 1929, W. Luce.

Macoupin County: Carlinville, 2 July 1890, W. E. Andrews. Gravelly and sandy soil near Carlinville, 13 July 1940, G. D. Fuller 2248. Carlinville, 23 August 1882, C. Robertson 2252.

Pope County: In Big Grand Pierre Creek northeast of Golconda, 19 July 1941, G. H. Boewe. Two miles east of Herod, 7 July 1931, J. Schopf 2242.

Union County. Mill Creek, 1 June 1932, Pepoon & Barrett 4520

Vermilion County: Seymour & Butts, 24 June 1880.

Wabash County: Wabash River at Mt. Carmel, 8 June 1894, J. Schneck. Sandy shore, Wabash River, 10 June 1932, Pepoon & Barrett 5139.

Wayne County: Shallow water, 13 June 1944, G. D. Fuller 8709.

Williamson County: Grassy Creek at Devil's Kitchen, 2 June 1941, McCree 806.

Key to the Illinois Species of Ruellia

1. Stem simple to slightly branched, leaves lanceolate, oblong to ovate.
   2. Calyx segments lanceolate, 2-4 mm. broad, capsule glabrous.... .....*R. strepens*
   2. Calyx segments 0.5-1 mm. wide, tapering to the tip, capsule pilose; flowers on slender peduncles .....*R. pedunculata*
1. Stem decumbent with bushy habit, leaves narrow, oblong, lanceolate, the tips blunt or rounded, coarsely villous; calyx 1.5-2.5 cm. long; capsule glabrous. .....*R. humilis*

Because of variations among some of the specimens of *R. humilis* Nutt., naming of intergrading varieties and forms has been omitted from the present treatment of Illinois species of this genus. Neglect of original descriptions may be a basic reason for the fact that much confusion seems to have existed for a century over the correct identification of *R. humilis* Nutt. and *R. ciliosa* Pursh. Many careful and reliable taxonomists have failed to note the obvious differences between *R. ciliosa,* as we have ordinarily identified it, and the original description by Pursh. As pointed out by Fernald (1945), the name *R. ciliosa* Pursh should be retained for a plant of the southeastern states and the Gulf Coast regions.

Ruellia strepens L. Sp. Pl. 634 (1753); Schneck (1876) 546; Patterson (1876) 29; Brendel (1887) 55; Gates (1926) 230; Pepoon (1927) 471; McDougall & Liebtag (1928) 231; Stover (1930) 25; McDougall (1936) 316; Jones (1942) 72; Fuller (1943) 98; Fernald (1945) 16; Jones (1945) 234.

Dipteracanthus strepens (L.) Nees in Linnaea 16: 292 (1842); Lapham (1857) 526; Forbes (1870) 318.

Hygrophila illinoiensis Wood ex. A. Gray, Syn. Fl. N. Am. 2^1: 327 (1878), erroneously assigned to Bull. Torr. Club 5: 41 (1874).

Ruellia strepens var. *cleistantha* A. Gray, Syn. Fl. N. Am. 1: 327 (1878).

Ruellia strepens f. *cleistantha* (A. Gray) S. McCoy in Am. Bot. 43: 24 (1937).

Type locality: "Habitat in Virginia, Carolina."

Range: Common in alluvial soil throughout Illinois, and from Pennsylvania to Iowa and south to Texas and Florida; flowering in Illinois from June to August.

Scott McCoy's paper (Am. Bot. 43: 24, 1937) gives an interesting account of observations from a specimen of *Ruellia strepens* transplanted to his garden. In June the plant bore flowers typical of the species and in autumn produced cleistogamous flowers.

Three specimens examined by the writer revealed that those collected from mid-August to November bore capsules closely packed in the axils of the upper leaves.

Adams County: Moist alluvial soil, eight miles south of Quincy, 8 September 1943, G. D. Fuller 3005.

Calhoun County: Along roadway through timber, Pere Marquette Study

Area, 11 October 1939, G. H. Boewe. Steep talus below Kampsville, 30 May 1933, Pepoon & Barrett 4399.

Champaign County: Sangamon River 15 miles west of Urbana, 21 June 1942, N. R. Piesbergen. University Woods near Urbana, 18 October 1941, G. N. Jones 15008. Roadside, Urbana, 6 July 1928, W. B. McDougall 52. Woods, Urbana, 17 June 1880, Seymour & Butts. Thicket, "St. Joe to Sidney," 16 September 1889, G. P. Clinton. Woods along Salt Fork River, near Urbana, 3 October 1943, G. N. Jones 16316. Near Urbana, 19 June 1941, G. N. Jones 13909. Grassy roadside, near Urbana, 28 June 1940, G. N. Jones 11818. Sangamon River bottoms near Mahomet, 29 September 1940, G. N. Jones 13120.

Fulton County: Sandy ground, Liverpool, 6 August 1891, H. S. Pepoon.

Hancock County. Crooked Creek bottom, 10 September 1916, F. C. Gates.

Kankakee County: Rich soil, 2 June 1872, E. J. Hill.

Livingston County: Moist woods, five miles south of Pontiac, 26 July 1944, G. D. Fuller 9196.

Macoupin County: Carlinville, 19 June 1882, C. Robertson 2277. Carlinville, 19 August 1889, W. E. Andrews. Carlinville, 19 June 1889, W. E. Andrews.

Macon County: Decatur, May 1896, I. W. Clokey. Three miles east of Decatur, cleared hill top, 30 May 1915, I. W. Clokey 2486.

Menard County: Moist ravine, New Salem, 10 September 1940, G. D. Fuller 3015.

Peoria County: Peoria, dry open woods, July 1892, F. E. McDonald. Rich woods, Peoria, July 1901, F. E. McDonald. Low grounds, Peoria, July 1887, F. E. McDonald. (Without number or date) Peoria, F. Brendel as *Dipteracanthus strepens.*

Pike County: East Hannibal, 3 June 1913, J. Davis 4623.

Pulaski County: Swampy ground one mile north of Ullin, 5 June 1941, G. H. Boewe.

Richland County: Near Olney. "Birdhaven," 8 October 1920, R. Ridgway 1320.

Sangamon County: Rich soil, Salisbury Township, 18 August 1941, G. D. Fuller 6537.

St. Clair County: Mascoutah (without number or date) W. Welch as *Dipteracanthus strepens.*

Union County: Rich soil, woods, 25 September 1940, G. D. Fuller 334.

Wabash County: In cut-over wooded area about one mile north of Bellmont, 29 May 1941, G. H. Boewe. Crawfish Bridge, 4 July 1893, J. Schneck. Gleck's field, 8 June 1878, J. Schneck. Mt. Carmel; a specimen in which the "flower is a deeper red and has a smaller flower, especially in the expanded portion, than the regular form." July 1880, J. Schneck.

Ruellia pedunculata Torr. ex. A. Gray, Syn. Fl. N. Am. 2^1: 325 (1878). Britton and Brown (1913) 3: 242; McDougall (1936) 316; Fuller (1943) 98; Jones (1945) 234.

Type locality: "Dry woods in W. Louisiana, J. Hale. Arkansas, Bigelow, Mrs. Harris."

Range: In dry, open woods in southern Illinois to Oklahoma, eastern Texas and Louisiana. Flowering from June to August and commonly called the Stalked Ruellia.

Alexander County: Rich woods two and one-half miles south of Diswood, 27 September 1931, Pepoon & Barrett 695.

Johnson County: Dry soil, Tunnel Hill, 26 May 1902, J. Schneck.

Pulaski County: In open woods on top of dry hill one and one-half miles northwest of Ullin, 18 June 1941, G. H. Boewe.

Saline County: On a rocky slope of Swartz Hill in northeast Saline County, 12 September 1931, Pepoon & Foster 1405.

Union County: Anna, 13 August 1880, A. B. Seymour. In the shady wood edge, along roads, 13 June 1927, G. L. Stout 2271. In open woods one mile northeast of the city limit of Anna, 29 August 1931, J. Schopf 1557. Open woods back of peach orchard, one mile northeast of city limit of Anna, 29 August 1931, J. Schopf 1544.

Ruellia humilis Nutt. in Trans. Am. Phil. Soc. 5: 182 (1837).

Dipteracanthus ciliosus (Pursh) Nees in Linnaea 16: 294 (1842); Lapham (1857) 526; Forbes (1870) 318.

Dipteracanthus noctiflorus β humilis (Nutt.) Nees in DC. Prodr. 11: 123 (1847).

R. ciliosa, var. *longiflora* A. Gray, Syn. Fl. 2: 236 (1878).

R. ciliosa var. *humilis* (Nutt.) Britt. in Trans. N. Y. Acad. Sci. 9: 185 (1890).

R. ciliosa sensu Mead (1846) 119; Babcock (1872) 146; Patterson (1874) 11; Hyatt (1875) 67; Patterson (1876) 28; Schneck (1876) 546; Brendel (1887) 55; Higley & Raddin (1891) 90; Huett (1897) 112; Snare & Hicks (1898) 16; Gleason (1907) 187; Gleason (1910) 166; Thone (1925) 105; Pepoon (1927) 471;

McDougall (1936) 316; Jones (1945) 234.—Not *R. ciliosa* Pursh (1814).

R. caroliniensis sensu Fuller (1943) 98. Non (Walt) Steud.

R. humilis var. *typica*, Fern. in Rhodora 47; 54 (1945).

R. humilis forma *grisea*, Fern. in l. c. 54.

R. humilis var. *frondosa*, Fern. in l. c. 54.

R. humilis var. *longiflora* (A. Gray). Fern. in l. c. 56.

R. humilis var. *expansa*, Fern. in l. c. 58.

Type locality: "Hab. On rocks in the upland forests and prairies." (Type or isotype, an Arkansas specimen from Nuttall in the Torrey Herbarium).

Range: In dry soil, along roads, on grassy banks, and dry slopes from southern Michigan to southeastern Nebraska, Iowa, and Missouri, and southward to eastern Texas, Louisiana, and northwestern Florida. Flowering in Illinois from June to September.

In this study the following characters have been used in order to separate the intergrading varieties and forms of this species: leaf shape, length of internode, kind and degree of pubescence, length and shape of sepals, and length of corolla. According to Nuttall's description of *R. humilis*, the plants are erect, hirsute, the leaves oblong-ovate, sessile, the peduncles 1-3-flowered, and the tube of the corolla twice the length of the laciniate, filiform calyx lobes. The leaves were indicated as "very similar to those of *R. strepens*, but sessile and not perfectly entire." The flowers were said to be pale blue and commonly two inches long. *Ruellia humilis* forma *grisea* Fern., with a more extreme pubescence than *R. humilis* var. *typica*, is scattered through the range of the latter. In *R. humilis* var. *longiflora* (A. Gray) Fern. the corolla is indicated as five to eight centimeters long, the veins and the margins of the leaves copiously villous-hirsute. *R. humilis* var. *expansa* Fern. has leaves described as ovate to ovate-oblong. They vary somewhat in size but agree in degree of pubescence.

Cass County: Sandy soil at edge of timber, five and one-half miles south of Beardstown, 27 June 1941, G. H. Boewe.

Champaign County: Urbana, 15 July 1878, A. B. Seymour. Urbana, 13 July 1880, A. B. Seymour. Urbana, 25 June 1897, G. P. Clinton. Grassy bank near Urbana, 1 August 1940, G. N. Jones 12686. Near Urbana, 20 July 1940, G. N. Jones 12531. Near Urbana, 10 September 1939, G. N. Jones 10714. Near Urbana, 24 June 1942, N. R. Piesbergen. Grassy bank near Urbana, 1 July 1940, G. N. Jones 12250. One mile east of Mayview, 18 June 1942, G. H. Boewe. One-half mile northeast of Rantoul, 1 July 1942, G. H. Boewe.

Christian County: One and one-half miles northeast of Stonington, 24 June 1942, G. H. Boewe.

Cook County: Calumet, dry hills (without name), 12 July 1865. Sandy soil, Custer Park (without date), W. S. Moffatt 570. Dry rocky places, Lemont, 29 June 1898, A. Chase 877. Dry rocky ground, Lemont, 29 June 1898, E. J. Hill.

Cumberland County: Hazel Dell Area, July 1939, C. S. Spooner.

Douglas County: Arcola, 2 July 1939, C. Mohr.

Hancock County: Prairie along Wabash R. R., 11 September 1916, F. C. Gates.

Henderson County: Sandy, open places, 27 May 1932, Pepoon & Barrett.

Jasper County: East of Wheeler, 9 June 1941, G. H. Boewe.

Jefferson County: Southeast of Centralia, 25 July 1930, L. Campbell & C. Alexopoulos.

Kankakee County: Three miles northwest of Bonfield, 18 July 1943, G. N. Jones 15942. Sandy swales, 11 June 1932, H. S. Pepoon 2258.

Macon County: Stevens Creek at Wabash, openings in timber, 1 July 1915, I. W. Clokey 2429.

Macoupin County: Carlinville, 21 June 1889, W. E. Andrews. Carlinville, moist soil in partial shade, 13 July 1940, G. D. Fuller 2249.

Mason County: Havana, 13 June 1894, T. J. Burrill. Havana, 27 June 1910, F. C. Gates 3471. 25 June 1942, G. H. Boewe. Havana, low, sandy forest, 12 July 1940, G. D. Fuller 2231.

Morgan County: Near Manchester, 30 May 1932, Pepoon & Barrett.

Ogle County: Oregon, "Liberty Hill," dry soil, 7 August 1883, M. Waite. Byron, dry hillsides, 17 August 1895, W. S. Moffatt 455. Oregon, rocky banks, 18 August 1895, W. S. Moffatt 455. Open woods White Pines State Park, 8 July 1942, G. D. Fuller 3435-0.

Peoria County: Peoria, dry prairies, July (date incomplete) F. E. McDonald.

Pike County: Along a steep wooded creek bank, 1 July 1943, G. H. Boewe. Roadside east of El Dara, 22 June 1931, L. R. Tehon.

Pope County: Rocky dry wooded hillside northeast of Golconda, 19 June 1941,

G. H. Boewe. Growing in oak-elm woods, 3 July 1931, J. Schopf 348.

Shelby County: Roadside two miles east of Windsor, 25 June 1940, G. H. Boewe. Two miles east of Tower Hill, 24 June 1941, G. H. Boewe.

Stark County: Gravel slope near Wady Petra, 9 July 1900, V. H. Chase 673.

Tazewell County: Sunny, sandy banks south of Pekin, 17 July 1932, Pepoon & Barrett.

Union County: Cobden, 25 July 1886, F. S. Earle. Pine Hill, rocky, shaded hillside, 11 September 1940, G. D. Fuller 266.

Vermilion County: Along Vermilion River between Oakwood and Collison, 23 June 1940, G. N. Jones 11620.

Wabash County: Dry, hard soil, 20 June 1902, J. Schneck.

Winnebago County: Above Rockford, 23 June 1933, H. S. Pepoon.

Summary

A study has been made of the genera and species of Acanthaceae occurring in Illinois, and keys have been provided for their identification. A county distribution of the species is included.

Only one species of Dianthera, *D. americana*, is known to occur in Illinois. *Justicia humilis* Michx. Fl. Bor. Am. 1: 8 (1803), was reported from southern Illinois by E. J. Palmer (1921) 134 as *Dianthera ovata* Walt. However, there appear to be no Illinois specimens in the herbarium of the Missouri Botanical Garden, where Palmer deposited his specimens, to substantiate this report. Three species of *Ruellia*, *R. strepens*, *R. pedunculata*, and *R. humilis*, are discussed, with supporting citations of Illinois specimens.

Ruellia *ciliosa* Pursh is a plant of the southeastern and Gulf-coastal regions. The writer follows M. L. Fernald in substituting the name *R. humilis* Nutt. for the northern-ranging species commonly found in Illinois, and formerly incorrectly known as *R. ciliosa* Pursh.

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CHEMISTRY

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* 1. Petroleum, Natural Gas, and Agriculture: Gustav Egloff, Universal Oil Products Company, Chicago.

* 2. Catalysis in the Oxidation of Oxalic Acid by Nitric Acid: J. H. Reedy, University of Illinois, Urbana.

* 3. Research Projects for Senior Chemistry Students: Sister Mary Martinette, B.V.M., Mundelein College, Chicago.

* 4. A Bomb in a Test-tube: G. Frederick Smith, University of Illinois, Urbana. (slides)

* 5. Electron Microscope in Analytical Chemistry: Robert B. Fischer, University of Illinois, Urbana. (slides)

* 6. Nutritional Studies on the Yeast, *Schizosaccharomyces pombe:* Frank M. Clark, University of Illinois, Urbana.

7. Chemistry of Synthetic Rubber: Rudolph Deanin, University of Illinois, Urbana. (slides)

8. The Use of Partial Differentials for the Estimation of Errors in Volumetric Analysis: F. Wm. Cagle, Jr., University of Illinois, Urbana.

*Not published.

THE USE OF PARTIAL DIFFERENTIALS FOR THE ESTIMATION OF ERRORS IN VOLUMETRIC ANALYSIS*

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This work was undertaken to determine what accuracy might be obtained in carefully conducted volumetric analysis. It is desirable to have such data in view of the immense popularity which volumetric schemes enjoy.

Development of Formulae

First let us develop partial differential expressions for probable error in volumetric analysis.[1] We shall derive these from the usual forms of the equations used for the calculations of volumetric results.

The following symbols shall have the meanings assigned:

S = Sample weight in grams.
ml = Volume of standard solution in milliliters.
e = Milliequivalent weight of substance sought or primary standard weighed.
N = Normality of standard solution.

If a sample of S (in grams) of a standard substance, whose milliequivalent weight is e, reacts stoichiometrically with a volume ml (in milliliters) of a solution, we may say that the normality, N, of the solution is given by:

$$N = \frac{S}{ml \times e} \qquad (I)$$

We may then write (e is a constant):

$$dN = \frac{1}{ml \times e}\partial S - \frac{S}{(ml)^2 \times e}\partial (ml) \qquad (II)$$

Now let us divide II by I to obtain expression III:

$$\frac{dN}{N} = \frac{\partial S}{S} - \frac{\partial (ml)}{ml} \qquad (III)$$

If a weighed quantity, S, of a sample of milliequivalent weight, e, should require ml milliliters of a standard solution of normality, N, for stoichiometric reaction, we may calculate percentage purity by formula IV:

$$\% = \frac{ml \times N \times e \times 100}{S} \qquad (IV)$$

By the scheme described above we can obtain expression V:

$$d\% = \frac{N \times e \times 100}{S}\partial (ml) + \frac{ml \times e \times 100}{S}\partial N - \frac{ml \times N \times e \times 100}{S^2}\partial S \qquad (V)$$

Combining expressions V and IV we derive VI:

$$\frac{d\%}{\%} = \frac{\partial (ml)}{ml} + \frac{\partial N}{N} - \frac{\partial S}{S} \qquad (VI)$$

If two solutions, one of volume, ml and normality, N, and the other of volume, ml′, and normality, N′, react stoichiometically, we may write expression VII:

$$N \times ml = N' \times ml' \qquad (VII)$$

From this we may write expression VIII:

*The material in this paper has been taken from a thesis presented to the Graduate School of the University of Illinois in partial fulfillment of the requirements for the degree of Master of Science (1945). It is presented with the permission of the Dean of the Graduate School and Professor G. L. Clark, under whose direction it was prepared.

$$dN = \frac{ml'}{ml}\partial N' + \frac{N'}{ml}\partial(ml') - \frac{N(ml')}{(ml)^2}\partial(ml) \qquad \text{(VIII)}$$

Dividing VIII by VII we obtain IX:

$$\frac{dN}{N} = \frac{\partial N'}{N'} + \frac{\partial(ml')}{ml'} - \frac{\partial(ml)}{ml} \qquad \text{(IX)}$$

It is necessary to give some consideration to the evaluation of the separate terms in equations III, VI, and IX. The term $\frac{\partial S}{S}$ is estimated from a knowledge of the sensitivity of the balance upon which the samples are weighed. The term $\frac{\partial(ml)}{ml}$ is estimated by careful weight calibrations of the burettes used. The pipets were standardized by the United States Bureau of Standards, and their error could be obtained directly from the certificate provided. In the case of equation IX, $\frac{\partial N'}{N'}$ is required. This is evaluated from previous calculations with equation III.

Application to Experimental Data

Table 1 contains data on the standardization of perchlorato-cerate solutions with samples of sodium oxalate. The over-all reaction is:

$$2\,H_2\,Ce\,(ClO_4)_6 + Na_2C_2O_4 = 2\,CO_2 + 2Ce(ClO_4)_3 + 6\,Na\,ClO_4$$

A sample of about 0.25 gram of pure dry sodium oxalate is accurately weighed on a balance of known sensitivity and dissolved in about 100 milliliters of 2N perchloric acid. This solution is then titrated (in the cold) with the unknown solution of perchloratocerate from a previously calibrated burette with the ferrous complex of 5-nitro-(1,10)-phenanthroline as the indicator. Samples 4 through 7 were taken from publication 2 listed in References with the knowledge and permission of the author.

Examples 1, 2, 3, and 4 in Table 2 concern the quantitative oxidation of sucrose by a perchlorato-cerate solution in 4N perchloric acid.[2] The over-all reaction is:

$$C_{12}H_{22}O_{11} + 26\,H_2Ce(ClO_4)_6 + 12H_2O = 11\,H_2CO_2 + CO_2 + 26Ce(ClO_4)_3 + 78\,HClO_4.$$

Examples 5, 6 and 7 in Table 2 represent data obtained for the titration of a weighed sample of purified ceric ammonium nitrate titrated with sodium oxalate in 2N perchloric acid.

Table 3 contains data on the standardization of a perchlorato-cerate solution with a standard solution of sodium oxalate and the reverse of this standardization.

It will be noted that in each table values of maximum, minimum, and average values for the terms evaluated are given. These are obtained by summing the individual terms to get the largest and the smallest summation and finally averaging these two values. This average calculated error is usually quite close to the observed variations in the analyses as inspection of the tabulated data will show.

References

1. If one is unfamiliar with this use of the partial differential expression, a standard textbook on calculus should be consulted. The following is recommended:
Granville, Smith, and Longley, Elements of the Differential and Integral Calculus: Ginn and Company, New York, 1943. Revised Ed.
2. Smith, G. F., Cerate Oxidimetry: G. Frederick Smith Chemical Co., Columbus, Ohio, 1942.

Table 1.—Standardization of Cerate

	Standard $Na_2C_2O_4$ Wt. in grams	∂s	$\frac{\partial s}{s}$	Titrating solution Vol. in milliliters	∂(ml)	$\frac{\partial(ml)}{ml}$	N
1.	0.2500	±0.0003	±0.0012	36.90	±0.04	±0.0011	0.1012
2.	0.2517	”	±0.0012	37.15	”	±0.0010	0.1011
3.	0.2503	”	±0.0012	34.81	”	±0.0011	0.1010
4.	0.1132	”	±0.0026	34.81	±0.06	±0.0017	0.04856
5.	0.1092	”	±0.0027	33.63	”	±0.0017	0.04849
6.	0.0883	”	±0.0034	27.16	”	±0.0022	0.04855
7.	0.0958	”	±0.0031	26.46	”	±0.0023	0.04856

Table 2.—Experimental Data inter-

	Wt. of sample g.	∂s	$\frac{\partial s}{s}$	Titrating solution Vol. in milliliters	∂(ml)	$\frac{\partial(ml)}{(ml)}$	N
1.	0.01250	±0.0003	±0.024	8.90	±0.06	±0.0067	0.1051
2.	”	”	”	”	”	”	”
3.	0.03371	”	±0.0089	24.50	”	±0.0025	”
4.	”	”	”	24.44	”	”	”
5.	2.5000	”	±0.00012	44.19	±0.04	±0.00091	0.1031
6.	”	”	”	44.16	”	”	”
7.	”	”	”	44.18	”	”	”

Table 3.—Experimental Data inter-

	ml′	∂(ml′)	$\frac{\partial(ml')}{ml'}$	ml	∂(ml)	$\frac{\partial(ml)}{ml}$	N′	$\frac{\partial N'}{N'}$
1.	23.01	±0.02	0.00087	25.00	±0.002	±0.00008	0.1051	0.002
2.	23.02	”	”	”	”	”	”	”
3.	23.01	”	”	”	”	”	”	”
4.	47.02	”	0.00042	50.00	”	±0.00004	0.1012	0.001
5.	”	”	”	”	”	”	”	”
6.	47.03	”	”	”	”	”	”	”

SOLUTIONS WITH PRIMARY STANDARD $Na_2C_2O_4$

Max.	$\frac{dN}{N}$ Min.	Av.	Max.	dN Min.	Av.
$\pm 2.3 \times 10^{-3}$	$\pm 0.1 \times 10^{-3}$	$\pm 1.2 \times 10^{-3}$	$\pm 2.3 \times 10^{-4}$	$\pm 0.1 \times 10^{-4}$	$\pm 1.2 \times 10^{-4}$
± 2.2 "	± 0.2 "	± 1.2 "	± 2.2 "	± 0.2 "	± 1.2 "
± 2.3 "	± 0.1 "	± 1.2 "	± 2.3 "	± 0.1 "	± 1.2 "
$\pm 4.3 \times 10^{-3}$	± 0.9 "	± 2.6 "	$\pm 2.1 \times 10^{-4}$	$\pm 0.44 \times 10^{-5}$	± 1.3 "
± 4.4 "	± 1.0 "	± 2.7 "	± 2.1 "	± 0.48 "	± 1.3 "
± 6.6 "	± 1.2 "	± 3.9 "	± 3.2 "	± 0.58 "	± 1.9 "
± 6.4 "	± 0.8 "	± 3.6 "	± 3.1 "	± 0.39 "	± 1.7 "

PRETED BY MEANS OF EQUATION VI

$\frac{\partial N}{N}$	% (Approx.)	Max.	$\frac{d\%}{\%}$ Min.	Av.	Max.	d% Min.	Av.
± 0.0020	98.48	± 0.022	± 0.012	0.017	± 2.2	± 1.2	± 1.7
"	98.49	"	"	"	"	"	"
"	100.28	± 0.013	± 0.0044	± 0.008	± 1.3	± 0.4	± 0.8
"	100.52	"	"	"	"	"	"
± 0.00052	99.92	$\pm 1.5 \times 10^{-3}$	$\pm 0.27 \times 10^{-3}$	$\pm 0.9 \times 10^{-3}$	± 0.15	± 0.027	± 0.09
"	99.88	"	"	"	"	"	"
"	99.91	"	"	"	"	"	"

PRETED BY MEANS OF EQUATION IX

N	Max.	$\frac{dN}{N}$ Min.	Av.	Max.	dN Min.	Av.
0.09673	± 0.0022	± 0.0018	± 0.002	$\pm 2.1 \times 10^{-4}$	$\pm 1.7 \times 10^{-4}$	$\pm 1.9 \times 10^{-4}$
0.09678	"	"	"	"	"	"
0.09673	"	"	"	"	"	"
0.09517	± 0.0014	± 0.0005	± 0.0009	$\pm 1.3 \times 10^{-4}$	$\pm 0.4 \times 10^{-4}$	$\pm 0.8 \times 10^{-4}$
"	"	"	"	"	"	"
0.09518	"	"	"	"	"	"

THE CHEMISTRY OF SYNTHETIC RUBBER*

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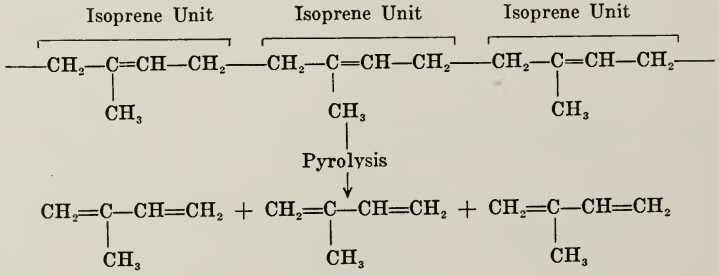
Introduction

In 1835 an obscure German chemist named Himly heated a sample of natural rubber and distilled out a volatile colorless liquid which was later named isoprene.[1]

During the next half century, several men reported the repolymerization of isoprene.[1, 2, 3] Then in 1882 Sir William Tilden suggested that if another and more economical source of isoprene were available, commercial polymerization of isoprene to synthetic rubber might be possible.[3]

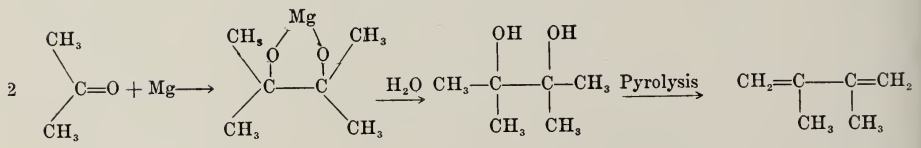
While isoprene itself was not readily available in large quantities, several similar substances were.

Pyrolysis of Natural Rubber

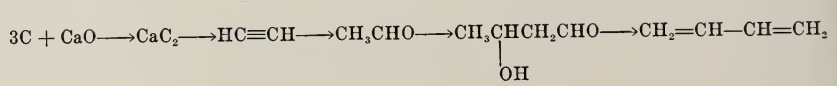


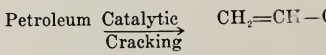
Preparation of Dienes

2,3-Dimethylbutadiene



Butadiene

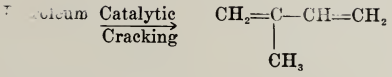




*Most of the investigations discussed in this report were carried out under the sponsorship of the Reconstruction Finance Corporation, Office of Rubber Reserve, in connection with the Government Synthetic Rubber Program. The author has tried to give credit to the many research chemists of the industrial, research foundation, and university laboratories cooperating with this program, whose work is summarized briefly here.

**Present address: Allied Chemical and Dye Corporation, Morristown, New Jersey.

Isoprene

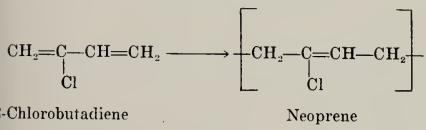


For example, bimolecular reduction of acetone produced pinacol hydrate, which was then dehydrated to 2, 3-dimethylbutadiene; this formed the basis of the German synthetic "Methyl Rubber" during the first World War. Later 1, 3-butadiene became available from several sources in large quantities and is now the most important material in synthetic rubber production. Very recently even isoprene became commercially available, but contemporary industrial practice heavily favors the use of butadiene for general purpose synthetic rubber.[4]

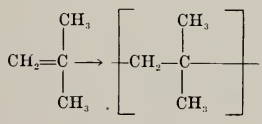
Several other types of synthetic rubber are produced in small amounts because they have special physical properties which make them useful in particular applications.[4]

For example, Neoprene has high oil resistance, and many of its uses in rubber hose, gloves, industrial shoes, and power transmission belts depend upon this. Vistanex or Butyl Rubber is very impermeable to gases and resistant to aging, making it valuable for use in inner tubes. Thiokol's uses for rubber hose and cable insulation depend upon its resistance to aging and solvents. Koroseal provides transparent elastic films for many purposes. Silicone greatly outlasts other rubbers in high temperature gaskets and similar uses. The present discussion, however, will be limited to butadiene polymers, which form the major portion of synthetic rubber production today.

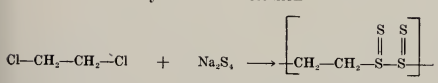
Other Synthetic Rubbers



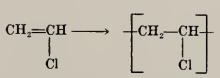
2-Chlorobutadiene — Neoprene



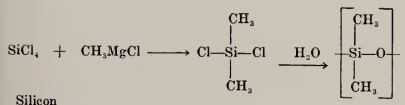
Isobutylene — Vistanex



Ethylene Dichloride — Sodium Tetrasulfide — Thiokol



Vinyl Chloride — Koroseal

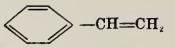


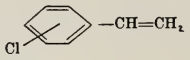
Silicon Tetrachloride — Silicone

The GR-S Polymerization System

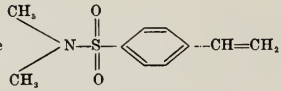
The physical properties of butadiene synthetic rubber are improved greatly by copolymerizing butadiene with various vinyl comonomers.

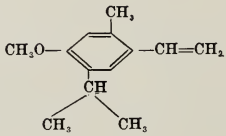
Comonomers

Styrene 

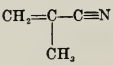
Monochlorostyrene 

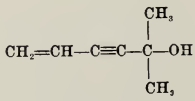
p - Cyanostyrene

p - (N,N - Dimethylsulfonamido)styrene 

2-Methyl - 4-methoxy - 5-isopropylstyrene 

Acrylonitrile

Methacrylonitrile 

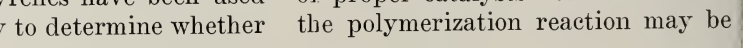
Dimethyl Vinylethinyl Carbinol 

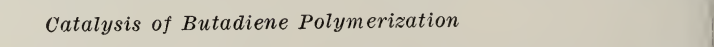
While styrene is the most common comonomer in GR-S rubber, many substituted styrenes have been used experimentally to determine whether they may produce improved synthetic rubber.[5] For example, monochlorostyrene is available in moderate quantities and has produced tires which wear considerably longer than GR-S. One *p*-cyanostyrene copolymer produced excellent preliminary tests, but this comonomer is so difficult to prepare that no further studies of it have been attempted. Attempts to produce superior synthetic rubber have led to the investigation of even such complex comonomers as *p*-(N, N-dimethylsulfonamido) styrene and 2-methyl-4-methoxy-5-isopropylstyrene.

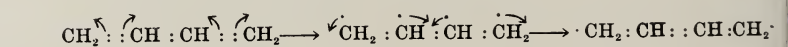
Acrylonitrile is another comonomer frequently used in industry. Preliminary studies indicate that methacrylonitrile may be far superior for tires, but this comonomer is practically unavailable for further tests at present.[6] Dimethyl vinylethinyl carbinol is an example of another comonomer which may offer the possibility of improving physical properties.[7]

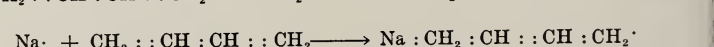
Butadiene copolymerizes very slowly, even under the influence of heat and pressure. With the addition of proper catalysts—or activators—the polymerization reaction may be

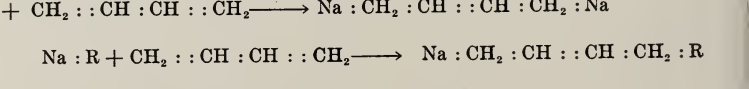
Catalysis of Butadiene Polymerization

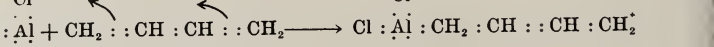
Thermal 

Alkali Metal 



Metal Alkyl 

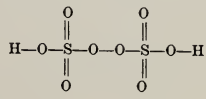
"Acidic" Metal Halide 

Free Radical 

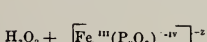
carried out readily under a wide variety of conditions.

Thus alkali metals,[8] alkali metal alkyls,[9] or so-called "acidic" metal halides[10] may be used to activate the carbon-carbon double bonds and thus catalyze extremely rapid butadiene polymerization. The synthetic rubber industry has generally preferred to use activators which decompose to yield free radicals which initiate the polymerization reaction.

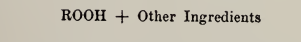
Free Radical Activators

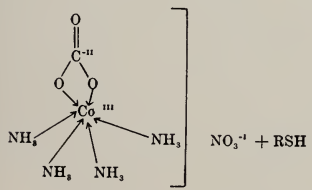


$K_3Fe(CN)_6 + RSH$

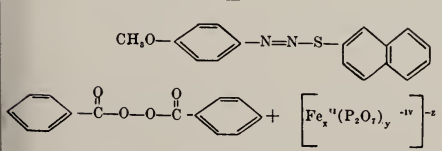
$H_2O_2 +$ 

ROOH + Other Ingredients

$O_2 +$  $+ RSH$



$NO_3^{-1} + RSH$



Polymerization Media

VAPOR	BULK	SOLUTION	SUSPENSION	EMULSION
Monomer	Monomer Comonomer	Monomer Comonomer	Monomer Comonomer	Monomer Comonomer
		Solvent	Water Protective Colloid	Water Emulsifier
Catalyst	Catalyst	Catalysts	Catalysts	Catalysts Modifier

While a number of types of activators have been developed,[7, 11] the chemistry of activation is very obscure and poorly understood. A survey of some of the activators frequently used indicates that most of them are good oxidizing agents, and suggests that initiation of polymerization may involve some oxidation reaction; but the specificity of these activator systems emphasizes the complexity and obscurity of this reaction.

The polymerization may be carried out in the vapor or bulk (liquid) phase,[8] in solution, [9, 10] suspension, or emulsion[12].

While the Russian synthetic rubber industry has concentrated upon vapor or liquid phase polymerization of butadiene using sodium catalyst, American and German synthetic rubber production is based upon emulsion copolymerization of butadiene with other comonomers, using free radical activators.

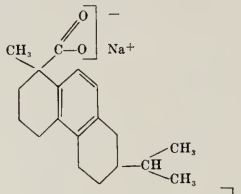
To disperse the organic monomer liquid in water various emulsifiers have been used.

In America ordinary fatty acid soaps[13] and certain rosin soaps (essentially sodium dehydroabietate)[14] are most commonly used, and other emulsifiers such as amine soaps have also been investigated.[15] In Germany, scarcity of natural soaps led to the use of various synthetic emulsifiers, such as Mersolat and Nekal.[16]

American Emulsifiers

Sodium Stearate $CH_3(CH_2)_{16}C(=O)-O^- Na^+$

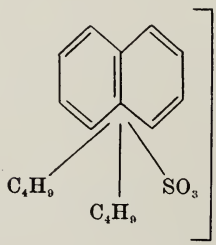
Sodium Dehydroabietate



Dodecylammonium Acetate $CH_3(CH_2)_{11}NH_3^+ \; CH_3C(=O)-O^-$

German Emulsifiers

Nekal



Mersolat $C_{14-17}H_{29-35}SO_3^- Na^+$

The GR-S Polymerization Reaction

When soap dissolves in water it forms plate-shaped or spherical micelles.[17]

The monomer is emulsified as droplets of organic liquid surrounded by soap molecules and suspended in the aqueous phase. Monomer in these droplets diffuses gradually into the soap micelle, where intimate interphase contact permits the activators to initiate the polymerization reaction. As the reaction proceeds, continuous diffusion of monomer into the micelle and polymerization there converts the micelle into a polymer-monomer particle surrounded by a layer of soap molecules which stabilize the latex. Eventually the monomer droplets are all consumed, and only the polymer-monomer particles remain. Then further polymerization of the monomer decreases its concentration in the particles, and the rate of polymerization decreases gradually as the reaction approaches completion.[18]

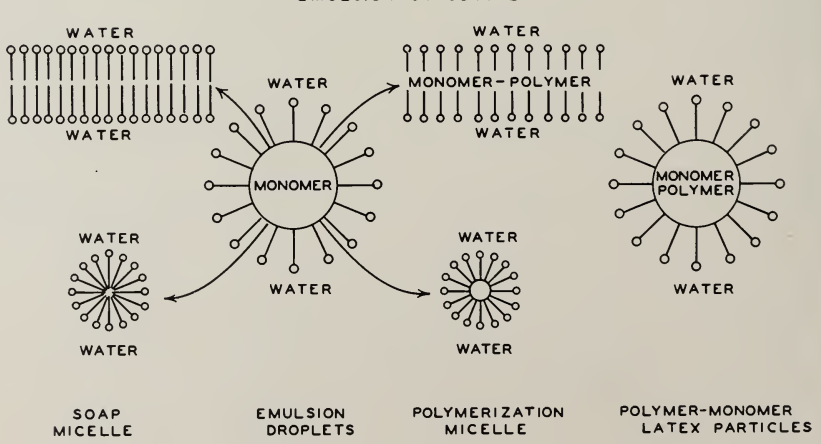


Fig. 1

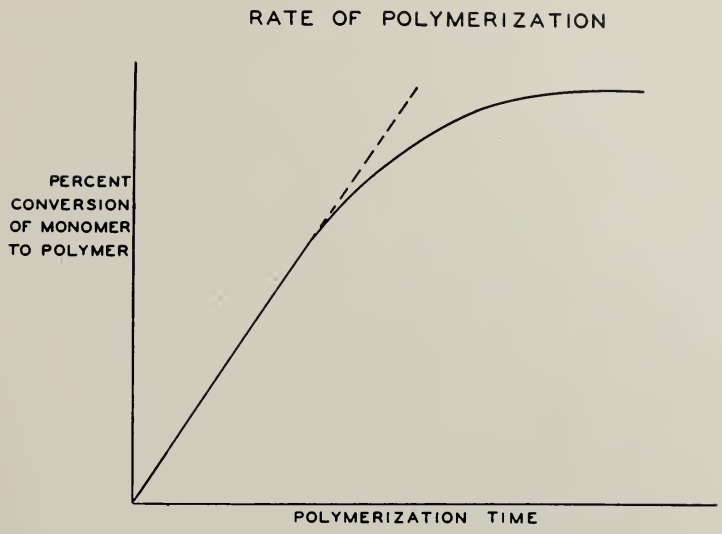
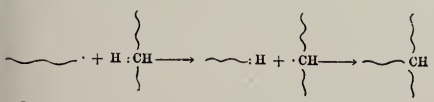


FIG. 2

As the polymerization reaction proceeds, the concentrations of the reactants and the physical conditions of the system change, and the molecular structure and physical properties of the resulting polymer vary continuously.[19] The growing polymer molecule may attack another polymer molecule, probably at the carbon-hydrogen bond adjacent to a vinyl group, and this chain transfer reaction produces a new free radical which grows into a cross-linked three-dimensional molecule.[20]



Repetition of this cross-linking reaction produces a "pincushion" shape polymer molecule.

If a modifying agent is used to regulate the growth of these cross-linked molecules, it terminates the growing molecules by a chain transfer reaction.[21]

As the modifier is consumed during the reaction, its concentration decreases and its effectiveness becomes less and less. The decreased frequency of chain transfer permits the molecular weight to rise, but it also permits more extensive cross-linking to form large three-dimensional molecules which are insoluble in benzene and are known as gel.[22] As the modifier concentration is decreased, gel formation increases rapidly. Molecular weight, which is measured by the intrinsic viscosity of the dilute benzene solution, increases as the modifier concentration decreases, as long as the rubber is entirely soluble; but when part of the rubber is excluded from the benzene solution as gel, the intrinsic

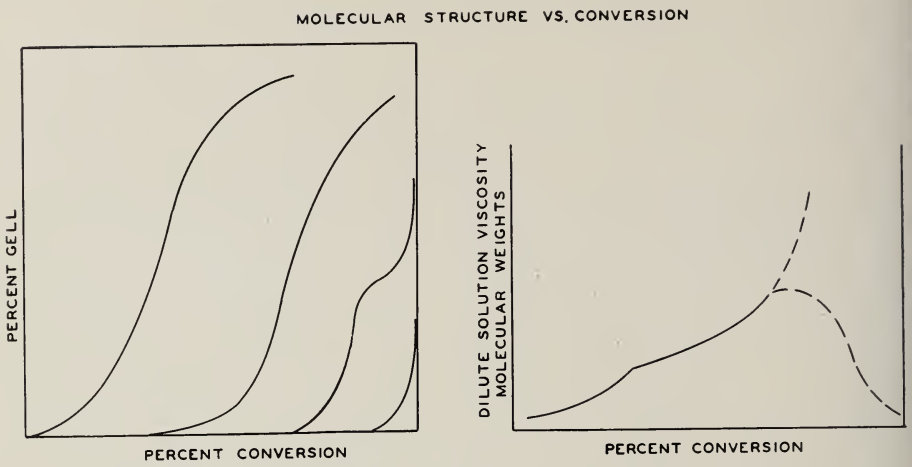


Fig. 3.

viscosity drops, while the actual molecular weight probably rises very rapidly.

Physical Properties of GR-S Synthetic Rubber

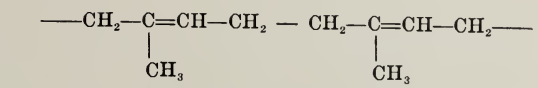
Corresponding with these changes in molecular structure there is a gradual change in physical properties.[23] As the molecular weight increases, the synthetic polymer resembles natural rubber more closely and the physical properties improve. Extensive gel formation however produces a structure quite different from natural rubber, and has a detrimental effect on physical properties. At high conversions, when gel formation becomes serious, Mooney viscosity increases, while processability and ease of breakdown decrease; these all indicate the formation of tough rubber which is difficult to process. Rebound (resilience) improves; but tensile strength, elastic elongation, rate of crack growth during flexing, and modulus all become worse, signifying a deterioration of rubber-like properties. Thus polymerization conditions must be carefully controlled to produce polymers with the desired physical properties.

Even at its best, however, synthetic rubber is very different from natural rubber, and much of this difference is believed to be due to differences in molecular structure.[24]

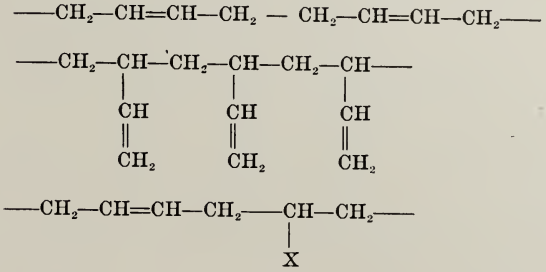
Natural rubber contains a 2-methyl group placed at regular intervals along the polymer chain, while polybutadiene does not. The position of monomer units in the polymer chain is very regular in natural rubber, whereas it is a random mixture of 1, 2- and 1, 4-addition in synthetic rubber, and would be even worse in synthetic polyisoprene. The occasional units of vinyl monomers add to the heterogeneity of the synthetic rubber molecule. Furthermore, in natural rubber the arrangement of the atoms at the double bonds is always *cis*, while in synthetic rubber it is a mixture of *cis* and *trans*.[25] Natural rubber contains long linear molecules, while synthetic rubber contains a heterogeneous mixture of cross-linked three-dimensional molecular structures. Finally the molec-

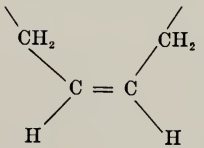
Molecular Differences Between Natural and Synthetic Rubber

Natural Rubber

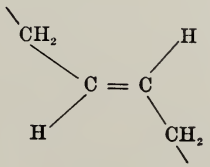


Synthetic Rubber





Cis



Trans

ular weight distribution is very different in the natural and synthetic polymers: natural rubber is more homogeneous, has less low-molecular weight material and a higher average molecular weight; while synthetic rubber has more low-molecular weight material, is more heterogeneous, and has a lower average molecular weight.[22, 26] All these differences contribute to the great difference between the two in processability and physical properties.

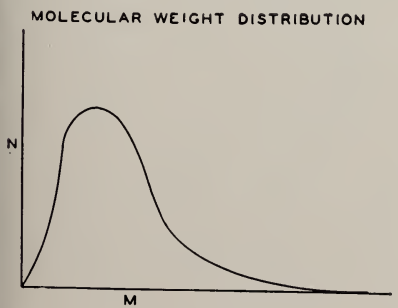


Fig. 4

Consequently we cannot call butadiene polymers "rubber substitutes" in the sense that they must resemble and replace natural rubber. Rather, we must recognize that synthetic polymers are distinctly different from natural rubber, and that therefore their processing, physical properties, and resulting uses must be designed to use them to best advantage, rather than merely to make them a bad substitute for something entirely different. During the war years, the urgent need for a rubber substitute prevented this functional approach; and consequently the future of synthetic rubber, in competition with natural rubber, is still uncertain. On the other hand, the special synthetics, which were developed and applied specifically

where they were superior, are certainly here to stay, and will become more and more important as they are developed further by industrial research.

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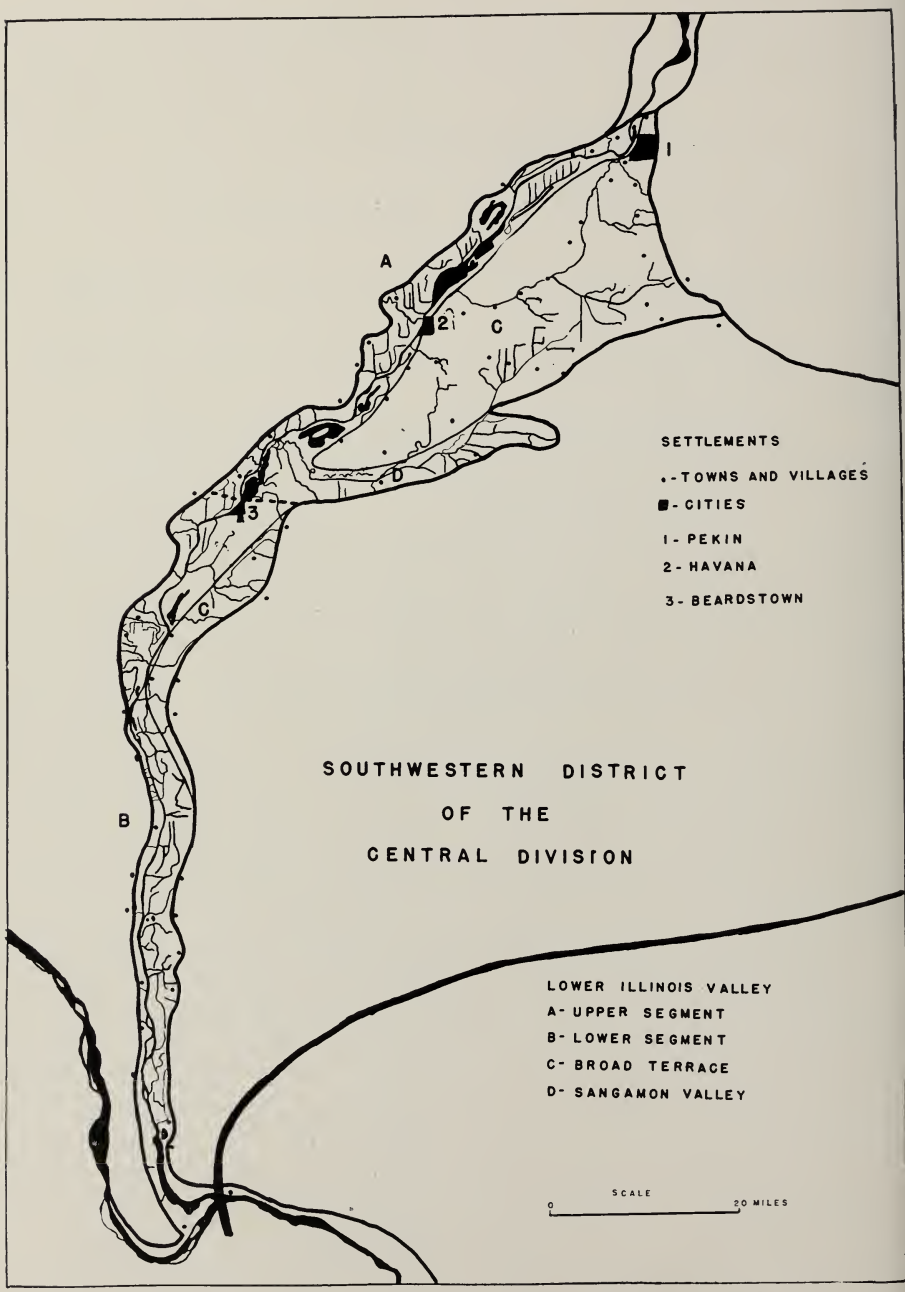

Fig. 1.—Occupance patterns of the Lower Illinois Valley.

OCCUPANCE PATTERNS OF THE LOWER ILLINOIS VALLEY

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From the confluence of the Kankakee and the DesPlaines rivers to the Mississippi River, approximately 250 miles to the southwest, flows the Illinois River in a valley which is one of the significant features of the geographic patterns of the State. The several sections of the valley which extend entirely across the Central Division of Illinois form the northern and western boundaries of the Eastern and Southwestern Districts. From the Kankakee-DesPlaines confluence to the Bureau bend is the Upper Illinois Valley whereas the Middle Illinois Valley extends from Bureau to Pekin. These two sections are a part of the Eastern District. The Lower Illinois Valley, which extends from Pekin to the Mississippi, a distance of 140 miles, is a portion of the Southwestern District (fig. 1).

The Lower Illinois Valley is composed of two well-marked and contrasting segments. The Upper Segment, which extends from Pekin to Beardstown, consists of a lake studded valley trough occupied by the braided river channel and a broad series of sand terraces interspersed with poorly drained depressions. These sandy terraces, with a maximum width of twenty miles, occupy the left side of the valley from the Shelbyville moraine to the Sangamon River whose meandering course has been canalized and straightened from its confluence with Salt Creek to the Illinois River. The Lower Segment, from Beardstown to the Mississippi River, consists of a north-south valley trough which becomes narrower and deeper with distance down stream until it swings away from the narrow ridge that is Calhoun County and merges with the wide eastward trending Mississippi trough.

Cultural Patterns

The Lower Valley is decidedly one of the problem areas of the State as well as a zone of conflict concerning the solution of those problems. The conflicting agents include the State, the twelve counties which line both sides of the river, several organized drainage districts, and the Army Engineers. The latter are concerned with drainage, navigation, and flood control.

Within the area lives a small dominantly rural population. Pekin, at the northern apex of the valley with a population of about 20,000, is the largest urban center, whereas, Havana (4000) and Beardstown (6500), river towns spaced at thirty mile intervals down the valley, are the only other towns with populations over 2500. Twenty incorporated towns of less than 2500 people, thirty unincorporated villages, and scattered rural habitations make up the rest of the population pattern.

Human interests and activities are concerned largely with the land of the valley and with the river itself. Outside of Pekin and the Orchard

and Kingston Mines across the river, manufacturing and mining are of little significance. Farming dominates the valley with as many as one quarter of the gainfully employed population engaged in that activity. The Upper Segment of the valley is a commercial grain area and the Lower Segment an area of general mixed agriculture, which in general is the less prosperous of the two as is indicated by federal income tax returns. Based upon 1940 returns, before the base was lowered and the rates increased to meet wartime conditions, less than 8% of the population of the Lower Valley received a yearly income sufficiently large to be taxed by the federal government. This figure varied from a high of 13% in the Pekin district of the Upper Segment to a low of less than 3% in the lower portion of the Lower Segment.

There is no other area, with the possible exception of the Ohio Border,where fishing and lumbering engage the activity of as many people as in the Lower Illinois valley. The braided and impounded Upper Segment is a more notable area for commercial fishing than the Lower Segment. These river activities do not produce large incomes nor do they contribute to a high standard of living. In a land of alluvial river bottoms, poor drainage, and flood menace, economic returns are low and the handicaps numerous. Although the river is a portion of a navigational link between the Gulf of Mexico and the Great Lakes, no advantages accrue to the Lower Valley as the decadent river towns attest. Flood is a constant menace to the towns and rural areas alike, and drainage of the low flat lands is a necessity to agricultural utilization over much of the area.

The Upper Segment

Although alike as far as the general problems are concerned, the Upper Segment of the valley presents some sharp contrasts to the Lower Segment. In the former, population and transportation patterns emphasize the two contrasting physical features, the valley trough and the broad terrace. The three largest towns, Pekin, Havana, and Beardstown, are evenly spaced at positions where the broad terrace meets a narrow portion of the river thus affording a satisfactory crossing of the valley trough by railroads and highways. Seven railroads and two highways focus on Pekin on its terrace site between the Shelbyville moraine and the valley bottom. Four of the railroads cross the terrace from the south, and two of them cross the river as does one highway.

Havana is served by several railroads, one of which terminates on the river front. The highway, however, crosses the river there and follows the river bluff both up and down on the west side of the river. At Beardstown, at the lower end of the Upper Segment, both the highway and two railroads cross the river.

Small river front towns are conspicuously lacking in the Upper Segment of the valley. On the broad terrace, alignments of small towns and villages conform to the railroad pattern. One follows the inner edge of a sandy terrace between Pekin and Havana, another occupies the outwash of the Shelbyville moraine

at the extreme eastern margin of the area, and a scattered group of village alignments radiate southward from Havana. In the valley trough a line of bluff-side villages connected by a valley highway occupy tributary valley mouth sites. However, the largest tributary, Spoon Creek, which joins the Illinois River directly opposite Havana, is not the site of a town.

VALLEY BOTTOM OCCUPANCE

Although the Upper Segment of the valley is a portion of the cash grain area of the State, a variety of land uses prevail. On the alluvial bottom lands, drainage is the outstanding problem. Organized drainage districts have dug ditches, built levees, and installed pumping stations to improve portions of the valley bottom which are consistently in corn crops. Improved valley bottom drainage, however, does not prevent or control floods and much of the land is unused. Lakes and vegetation choked sloughs, some of which are set aside as wild life refuges, are conspicuous elements of the valley bottom, whereas roads and farmsteads are limited to the bluff side margins and to the intermittent areas that have been ditched and drained.

BROAD TERRACE OCCUPANCE

The broad terrace on the left side of the Upper Segment presents a different pattern of occupance. Well-drained sandy terraces contrast with adjacent sloughs and depressions in which drainage ditches and levees have been constructed by organized drainage districts. The Sangamon and Mackinaw rivers and Quiver Creek flow through portions of the depressions which divide the area into a series of terraces. The Mackinaw describes a sharp arc from the Shelbyville moraine to the Illinois River about two and one-half miles below Pekin, separating the terrace site of the city from the remainder of the sandy outwash which lies along the margin of the moraine from the Illinois River to the vicinity of Emden. Three of the railroads follow this terrace to Pekin, and along them is one of the alignments of villages.

From the Mackinaw River to Quiver Creek, about four miles above Havana, is a crescent-shaped sandy terrace that is separated from the outwash area adjacent to the Shelbyville moraine by an extensive depression which has been ditched and drains into Quiver Creek. The railroad from Pekin to Havana follows the inner margin of the terrace along which the towns are aligned at a distance of four to six miles from the river. Farmsteads, many of which are old, are scattered over both terrace and depression. The cash grain farming of the Grand Prairie extends over the Shelbyville moraine and into the Upper Segment of the valley. Corn is the major crop although small grain, especially wheat, is much more important on the lighter soils of the terraces than it is on the heavy soils of the depressions. About 4500 acres of the sandy terrace, above Quiver Creek between Forest City and Clear Lake on the valley bottom, are given over to the Mason County State Forest.

From Quiver Creek to the Sangamon is another extensive terrace which is interrupted in several places by depressions which have

been ditched into the Sangamon. At a point near the upper end, where the Illinois River flows against the terrace, is the town of Havana from which railroads and highways radiate. Although there is much unused land, cash grain farmsteads are scattered over the entire terrace.

The southern edge of the broad terrace is marked by the Sangamon River, which enters the area from the south and follows the flat bottom of the narrow valley trough westward to the Illinois River. The meandering course of the river has been straightened and, except for the lower ten miles, has been enclosed by levees leaving oxbows and meander scars scattered over the valley floor. The boundary between Mason and Cass counties, which followed the original course of the river, now follows a devious path back and forth across the river. Roads and farmsteads are not numerous on the valley floor of the Sangamon.

The Lower Segment

Beardstown marks the end of the Upper Segment and the beginning of the Lower. At that point the valley narrows to about ten miles in width, and the levees, which enclose the valley trough throughout most of its lower course, are established on both sides of the river. On the right side they begin at Fulton County line about twenty miles above Beardstown. On the left side the levee begins in the Sangamon Valley and extends to the river front entirely enclosing the valley floor on which Beardstown is situated. Drainage from the area is pumped from ditches into the river at the site of the new LaGrange lock and dam six miles below the town.

From a width of ten miles the Lower Segment narrows to less than two and one-half miles and the river bluffs rise to several hundred feet above the valley floor. The river pursues a direct course on the right side of the valley leaving only a narrow strip of valley floor on that side, especially in the lower narrow course. Except for LaMoine River and McGees Creek in the upper portion of the Segment, the tributaries on the right side of the valley consist of short narrow valleys locally known as "hollows." The floor on the left side of the valley is considerably wider and is interrupted at regular intervals by Indian, Apple, Big Sandy, and Macoupin creeks.

The left valley floor is protected by a levee from Beardstown to Macoupin Creek, but since the river flows on the right side of the valley only the upper twenty-five miles of that side are protected. Ditches and pumping stations drain much of the valley bottom on both sides of the river except in times of high water on the Illinois when much of the bottom land is flooded. Corn and hay crops are produced on the alluvium of the valley bottom, although graded unsurfaced roads and farmsteads are distributed over much of the bottom land, towns and villages and surfaced highways occupy the better drained position at the margin of the valley trough or the bluffs just above the valley.

Meredosia (1000) and Naples (260) are river front towns on a low sandy terrace that extends about twenty-five miles down the left side of the valley from Beardstown. A railroad crosses the river at Meredosia as does another at a point five

miles below Naples. The rest of the villages are aligned on the bluff-side highway in the mouths of tributary valleys where spring freshets cause considerable damage.

At Hillview in the valley of Hurricane Creek, forty miles above the Mississippi, a railroad crosses the Illinois River directly to Pearl in Hill Creek valley. Twelve miles farther down the valley at Eldred, a railroad spur enters the valley by way of a tributary, likewise known as Hurricane Creek, turns southward and terminates on the valley bottom nine miles farther down the valley opposite the town of Hardin, the county seat of Calhoun County. A large movable elevator type bridge, the last one down the valley, and an improved highway cross the valley there. In this manner the railroad serves Calhoun County, which is the only county in the state without a railroad within its boundaries.

Because of the better drained conditions of the right side of the valley the major highway has been constructed on that side, but it does not follow the valley all of the way. At Hardin, about fifteen miles above the Mississippi the highway crosses the valley on the bridge noted above and continues southward to Pere Marquette State Park and the town of Grafton at the Illinois-Mississippi confluence. Pere Marquette State Park occupies about seven square miles on the wooded bluffs at the left side of the lower end of the Illinois Valley.

Extra-Regional Relationships

Grafton, a town of 1100, holds the same relative position to the Illinois Valley that Cairo holds to the Ohio, both of which are indicative of the general significance of rivers as highways in America. Like the Ohio, the Illinois River is part of a national navigational system under the jurisdiction of the Army Engineers who dredge its channel and erect dams and levees. As such the Lower Illinois Valley, along with the rest of the river, assumes national significance. That the national relations are of little consequence to the local area is obvious. Like the Ohio, the Lower Illinois Valley is subject to high water and infrequent disasterous floods; these are of significance to the local area. The river is used for sanitary drainage as well as for navigation on an extra-regional basis; it is a source of water supply and fish within the area. It is quite unsatisfactory to consider the Lower Valley as a corridor in the complete geographic sense, yet many of the corridor problems are there. The major one is the conflict of indigenous and extra-regional interests. Although indigenous interests are in many instances based upon unfortunate natural environmental associations which result in poverty, it is unjust to condemn without exhaustive consideration of all facts concerned and without offering advantageous alternatives. The extent to which occupance is satisfactorily readjusted to natural environmental conditions by all people concerned, the greater will be our state and national advancement toward a long enduring maturity. River valleys are included among our problem areas, and the Lower Illinois Valley is not one of the exceptions.

THE POTTERY INDUSTRY IN McDONOUGH AND WARREN COUNTIES, ILLINOIS*

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The production of clays and clay products in Illinois is valued at approximately $32,000,000 annually. This is the third largest mineral industry in the State following coal and petroleum. In 1946, the production of pottery and whiteware in Illinois accounted for about one-third of the total value of all clay products made in the state. Illinois is surpassed by Ohio, New Jersey, New York, California, and Pennsylvania in the manufacture of pottery.

The potteries in Illinois are concentrated in two general areas. The largest, in terms of numbers of establishments, is the Chicago area. In Chicago itself, Antioch, Dundee, Crystal Lake, and Elgin, there are eighteen concerns manufacturing a variety of products. It can be generally stated that the large market and excellent transportation are the chief factors for the concentration of potteries in this area. The potteries in smaller towns near Chicago utilize the large market, but lower taxes, intelligent labor and, in some cases, financial support from the towns, influenced their establishment in the perimeter of Chicago.

The remaining potteries in the state, with the exception of the Case Manufacturing Company in Robinson which produces sanitary ware, are located in western Illinois.

The potteries in western Illinois can be divided into three groups determined by factors which controlled their original establishment. The first group are those potteries located in White Hall. The basic and dominant condition which determined their location was the existence of excellent stoneware clays in and around White Hall and the proximity of coal. These clays were found in abundance and in such a state that mining could be done easily. The existing clay banks attracted potters who began to manufacture stoneware, and the two potteries of today, Ruckell's Pottery Company and The White Hall Sewer Pipe and Stoneware Company, are the result of these natural resources. Also the establishment of the Illinois China Company in Lincoln can be traced to the stoneware plant in Roodhouse where again the fine White Hall stoneware clays were utilized.

The second group of potteries is located farther north at Macomb and Monmouth. Again, clays of the Pottsville formation, found in the vicinity of Colchester, were of such quality that potters were attracted, and they established potteries using only the local clays. Because of the potteries, a concentration of semi-skilled workmen gradually became concentrated in this area, and the town of Macomb and adjacent villages, with a large number of their population engaged in clay working industries or indirectly dependent

*This paper is a revised portion of a thesis presented for the degree of Master of Science in Geography at the University of Illinois, August 1946.

upon them, became ceramic conscious. With existing plants and trained labor, it was a natural step to improve upon their products, and gradually fine clays and materials were brought in. However, the local clay was the dominant factor in their early establishment. The potteries of this group are the Macomb Pottery, Illinois Electric Porcelain in Macomb and Western Stoneware in Monmouth.

The third group consists of diversified potteries which have no common physical factor in their early establishment. The physical environment played a subordinate role and human factors were decisive in their location. These varied factors would have to be discussed as they apply to the individual pottery. This group consists of the Abingdon Potteries Incorporated located in Abingdon and the Morton Pottery Company in Morton.

The Potteries of Monmouth and Macomb

THE MACOMB POTTERY

In Macomb the former Buckeye Pottery Company, makers of stoneware, was taken over in 1939 by the Haeger Potteries. The name changed to the Macomb Pottery and it began to make the Haeger style of art pottery. The old Buckeye Pottery made only stoneware products and utilized only the local clay found in abundance near Colchester. The competition from China and finer grades of earthenware had forced the Buckeye Pottery Company into the state of bankruptcy in 1938.

Over sixty years ago in Dundee, Illinois, the Haeger family began to manufacture brick using the local clays. Gradually the kilns were used in burning other forms of pottery until today no brick is made at all and the entire output is art pottery.

Art pottery, a relatively new trend, is noticeable in the pottery field today, and it can generally be stated that the comparatively newer potteries produce art ware. In the older pottery centers of Ohio and New Jersey, more dinnerware and sanitary ware are made. In these older potteries a tremendous amount of this type of ware was and is produced, and consequently the more recent potteries had a greater commercial opportunity in the making of art pottery. This can be seen in the great numbers of art potteries in the southern California area. This area is the most recent pottery center to be developed and at present is experiencing a rapid expansion.

Another factor in the more recent impetus in the the manufacture of art ware is the result of the War. The seizure of Moravia, Bohemia, and Slovakia by Germany decreased our imports from those areas as early as 1939. Later, at the outbreak of the war, little pottery made in the European centers came to this country. Also during this period changes in duty rates and regulations governing imports further decreased the small amount of European pottery coming to this country. The war, of course, also halted all importation of Japanese ware and seriously decreased that made in China. The lack of foreign products and resulting competition resulted in a large expansion of the ceramic industry in this country, especially in the gift and art ware fields. Many potteries began to make art ware in addition

to their main products, and new potteries sprang up to meet the domestic need.

Haeger Potteries diversified its line to include a great deal of ware of the type formerly made in Japan and Czechoslovakia. The pottery experienced a rapid rise in production and soon outgrew its building in Dundee. The Buckeye Pottery in Macomb, with its buildings and machines intact, and the semi skilled labor in the city, was therefore an excellent location in which to overflow. Further, Macomb, from its beginning, has been ceramic conscious due to the fine local clay and relatively large clay working population. The city was anxious for the pottery to resume operation after the Buckeye pottery declared bankruptcy and made a cash donation to the Haeger Pottery to take over the plant.

The Haeger Potteries are the world's largest producers of art ware and the markets are nation wide. Some pottery is exported to Canada, Hawaii, Phillipines, South America, England and other countries of the world. Sales offices are located throughout the country, and the majority of the pottery is sold through their own sales organization; jobbers market a small amount. The finished products are transported primarily by the C. B. & Q. Railroad. Trucks transport an ever increasing amount, usually when the distances are short.

The plant employs an average of 160 people. The amount of local labor is practically 100 percent, however, a small number of supervisors and administrators came from the pottery in Dundee. The skilled workmen represent about 15 percent of the total labor. They are for the most part mould makers and decorators. The designers, of which some are internationally famous, are located in Dundee, not in Macomb. Their designs are sent to Macomb where they are utilized in producing Haeger pottery. The plant has the capacity to produce 8,000 pieces of art pottery daily.

MATERIALS USED IN ART POTTERY

Years ago only the Colchester clay was the basic material used in the manufacture of stoneware. But today, materials are brought in from afar and the local clays are no longer used. The factory is situated on the Chicago, Burlington, and Quincy Railroad and the raw materials are brought in by rail. Kaolin is brought in from Georgia. Over three-fourths of the kaolin produced in the United States comes from a belt extending from Taylor County in western Georgia to Richmond County in the eastern part of the state extending into South Carolina. Kaolin is used in the manufacture of art ware to impart whiteness to the products being made and to give refractoriness to the products. Ball clay is also used in large amounts in the production of art ware. It is of sedimentary origin and usually more or less colored by impurities. These impurities tend to make the clay plastic and permit its moulding. Ninety-five percent of the ball clay produced in the United States comes from a belt extending from Graves County in southwestern Kentucky to Weakley, Henry, and Carrol counties in Tennessee. Feldspar is used as a component of white wares and semi-porcelain serving as a flux

binding the mass together. It is obtained from the Black Hill region of South Dakota. Quartz is used to prevent excessive shrinkage and obtained from LaSalle County, Illinois. Small amounts of special glazing material of various types are used depending on the type of ware being made. The kilns burn natural gas piped from Texas. Oil can be used as a fuel if necessary and is obtained a few miles south in the vicinity of Colmar.

THE ILLINOIS ELECTRIC PORCELAIN COMPANY

There is only one pottery in western Illinois which makes electric porcelain. It is the Illinois Electric Porcelain Company located in Macomb.

In 1884, C. W. Kettron came to Macomb from the southern part of the country. He learned his trade as a potter in Mississippi, and in Macomb he worked as a turner producing stoneware items of various shapes and sizes. In a few years Kettron went to Ohio, and worked in and observed many of the potteries located around the pottery center of the United States—East Liverpool. Here he saw a relatively new trend in the field of ceramics—the production of electric appliances. He believed that with the harnessing of electrical power, a great market for electric porcelain would arise. He returned to Macomb, dissolved his interests in the stoneware establishment, and interested the already ceramic-minded citizens of Macomb in this new and promising field of pottery. In Macomb there were the existing kilns which could be converted easily to the firing of porcelain, the large supply of semi-skilled labor and the complete lack of competition, as the nearest plant producing electric appliances was hundreds of miles distant. A few highly skilled technicians were brought to Macomb from East Liverpool to form the nucleus of the new concern. C. W. Kettron was the principal figure in the establishment of the Illinois Electric Porcelain Company in 1910, and his son, H. P. Kettron, is the president of the company today. The raw materials in the manufacture of electric porcelain are of unusually high standards. The only local material used is the Colchester clay which is utilized in making saggers. All other materials are transported from greater distances. The kaolin is an extremely fine grade imported from south England which is mined close to the English Channel. At present, no kaolin yet produced in the United States is quite equal to the English clay in the necessary qualities needed to produce electric porcelain. The ball clay is obtained in Kentucky. The feldspar is brought from the Abingdon Potteries Inc. who grind the feldspar which is mined in the Black Hills of South Dakota. The flint is ground from fine quartz obtained in Ottawa, Illinois. The glazing materials consist of ball clays, feldspar, flint, and other secret ingredients. Most plants add small, but varying amounts of talc, soda ash, silicate of soda, dextrose, etc. to accomplish correct special characteristics. The materials are brought in by the C., B. & Q. Railroad which has a spur leading to the factory door. The fuel used for firing is crude oil obtained in fields in the vicinity of Colmar.

The market for electric porcelain is country wide, and some goes to Europe, Canada, and South America. The company has sales offices throughout the United States and in Europe, and the products are marketed through their own sales organization. The finished products are transported primarily by the C., B. & Q. Railroad. However, if time is a critical factor, trucks usually handle the transportation. During the war air express was frequently used. The products were trucked to Moline and then shipped to their destination by air. Critical items in this way could reach any section of the country on the same day they were shipped from the factory.

The establishment employs 300 to 350 people all of whom come from Macomb or the adjacent country. The amount of highly skilled labor is approximately 15 percent. About 75 percent of the labor is semi-skilled. The workmen learn their trade at the plant.

The plant produces about 7,000 tons of electrical porcelain annually in the form of insulators, knobs and cleats, switch covers, and chemical porcelain such as valves and pipes of various types.

THE WESTERN STONEWARE COMPANY

Years ago, it was believed that coal could be found in the vicinity of Monmouth, the home of Western Stoneware Company. In search of coal, a clay was discovered which was of excellent grade for the manufacture of tile and brick. Because of this clay, the Monmouth Mining and Manufacturing Company was established in 1872 and began to manufacture tile and sewer pipe and a smaller quantity of brick. Twenty years later a number of men, of whom William Hannah was the principal figure, organized the Monmouth Pottery which utilized the nearby clay and produced stoneware jars, jugs, churns, etc. From these two concerns, in 1900 the Western Stoneware Company was established. It was a stock company and was fostered by the local men who had developed the two preceding clay working industries. The clays near Monmouth were still used in the beginning, but later a superior stoneware clay was found in the Pottsville formation in the vicinity of Colchester. The company leased hundreds of acres in this area and began to mine the clay and transport it to Monmouth. Today clay from the same mines is used in the production of stoneware.

The Colchester clay is brought in by rail to the factory at the rate of about a carload daily. The site of the industry is on the C., B. & Q. and the Minneapolis and St. Louis Railways. The C., B. & Q. transports the clay from the Colchester area. In 1927 the company began to make art pottery along with the stoneware products. This necessitated bringing other materials from other sections of the country. The manufacture of art pottery demanded kaolin which was obtained from Georgia, ball clay from Kentucky, flint from LaSalle County, Illinois, and feldspar from the southeast, primarily North Carolina. Both railways, but primarily the Minneapolis and St. Louis, bring in these raw materials.

Stoneware is the principal product produced and the art pottery,

though increasing, is secondary.

The fuel for the kilns is crude oil obtained from the relatively old oil fields in the vicinity of Colmar.

The markets for the finished products are country wide. The majority of the pottery reaches the market by the company's sales organization which has sales offices located in many sections. The major portion of pottery is transported by the C., B. & Q. with the Minneapolis and St. Louis Railroad handling a smaller amount. When the products are transported but a short distance, trucks often are used.

The company employs approximately 400 people of which 15 percent are skilled. The skilled labor again consists of the mould makers, designers, and decorators. The labor is all from in and around Monmouth. The skilled workmen learn their trade by experience in the factory.

The plant produces 1000 carloads of ware annually of which the majority is flower and garden ware. The company uses the trade name of "Maple Leaf" for their stoneware.

The company has also a small branch operating in Macomb which makes only terra cotta flower pots. The clay used is of local origin, and the products are made by stamping or pressing the clay into shape and then firing the ware at a low degree of temperature. The plant employs about twenty men, all of whom are from Macomb.

It is unlikely that in the relatively near future new potteries will be established in western Illinois. However, the existing potteries producing art ware and specialty products should experience a slight expansion within the next few years.

It has been mentioned that the only physical factors to attract new industries are the stoneware clays, but the existing potteries more than meet the local need. In other types of pottery, materials would have to be brought in from great distances and also the markets are relatively far. Freight rates and transportation in Western Illinois are not such that they in themselves would attract industry. The only inducement or positive factor would seem to be a comparatively large financial bonus from a specific district or town. The existing stoneware potteries of the State, excluding Western Stoneware Company, should remain about the same. The products produced are of relatively low value, and therefore the markets are restricted to a definite locality. Also the potteries should be located near the source of clay. Transportation costs are in this case a limiting factor. In the case of Western Stoneware Company they are almost fully dependent upon the florist trade, and they should experience the same trend as the art ware pottery.

It has been mentioned that art ware has experienced a great rise in production to meet the increasing domestic needs since the war. No doubt in the near future, some art ware will be imported from Europe and China. However, importations probably will never reach such relative proportions as existed before the war. The art ware potteries, however, will manufacture an increasing variety of products, and many experiments and changes will take place in art ware in an effort to keep the domestic markets. It is interesting to note that in times of depres-

sion art ware potteries are the first to suffer and usually are the hardest hit, but, on the other hand, in prosperous eras the demand for art ware increases out of proportion to other types of pottery.

Electric porcelain is related to construction and improvements in rural areas. The Rural Electrification Administration, a federal act to extend electricity in rural areas all over the country, did much to increase demands for electric porcelain. Also a great deal of porcelain is being sent to Europe and other countries engaged in reconstruction and internal development.

TEACHING OF CONSERVATION OF NATURAL RESOURCES IN ILLINOIS COLLEGES AND UNIVERSITIES

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Introduction

Statement of purpose.—The purpose of this paper is to evaluate the part that the Colleges and Universities of Illinois are doing in promoting education in the field of conservation of natural resources.

Conservation seeks to gain for society the most efficient development and wise utilization of our natural resources. In the settling and building of this nation, the people of the United States have proceeded to waste and destroy our natural endowment at an unprecedented rate; however, partially through the efforts of the conservation minded men of the nation, this onslaught has not proceeded to the point of self destruction. It is fortunate that the conservation movement began to gain power when it did so as to slightly retard the vast wasteful inroads made into the nation's resources.

Even in Colonial times there was evidence of interests in conservation, but the real significant beginnings are not noted until the latter part of the 19th century. In 1873 and again in 1890 the American Association for the Advancement of Science presented a petition to congress urging them to take action to conserve the natural resources of the nation. Probably as the result of these petitions, there was established in 1891 the Bureau of Forestry in the Department of Agriculture and the first National Forest Reserve was set aside.

Under the leadership of Theodore Roosevelt, the nation made tremendous advances in conservation of natural resources. A great landmark was the Conference of Governors that Roosevelt called in 1908. This meeting marks the beginning of 41 State Conservation Commissions.

It is true that great losses were sustained before the destructive wave was somewhat retarded. The great hordes of passenger pigeons have been swept from the skies forever and only a few remnants are left of the huge forests which once blanketed the nation. The small groups of buffalo left in the West can't even echo the glory that once was theirs as they roamed the Great Plains by the hundreds of thousands.

The objectives of conservation vary within the field. Conservation of the non-renewable resources like iron, zinc, coal and petroleum consists mainly of insuring non-wasteful mining conditions, efficient use of the product and the saving of the scrap. Renewable resources like forests and wildlife can and should be renewed by close control. Soil is a resource that can be easily damaged but need not be if proper conservational practices are employed.

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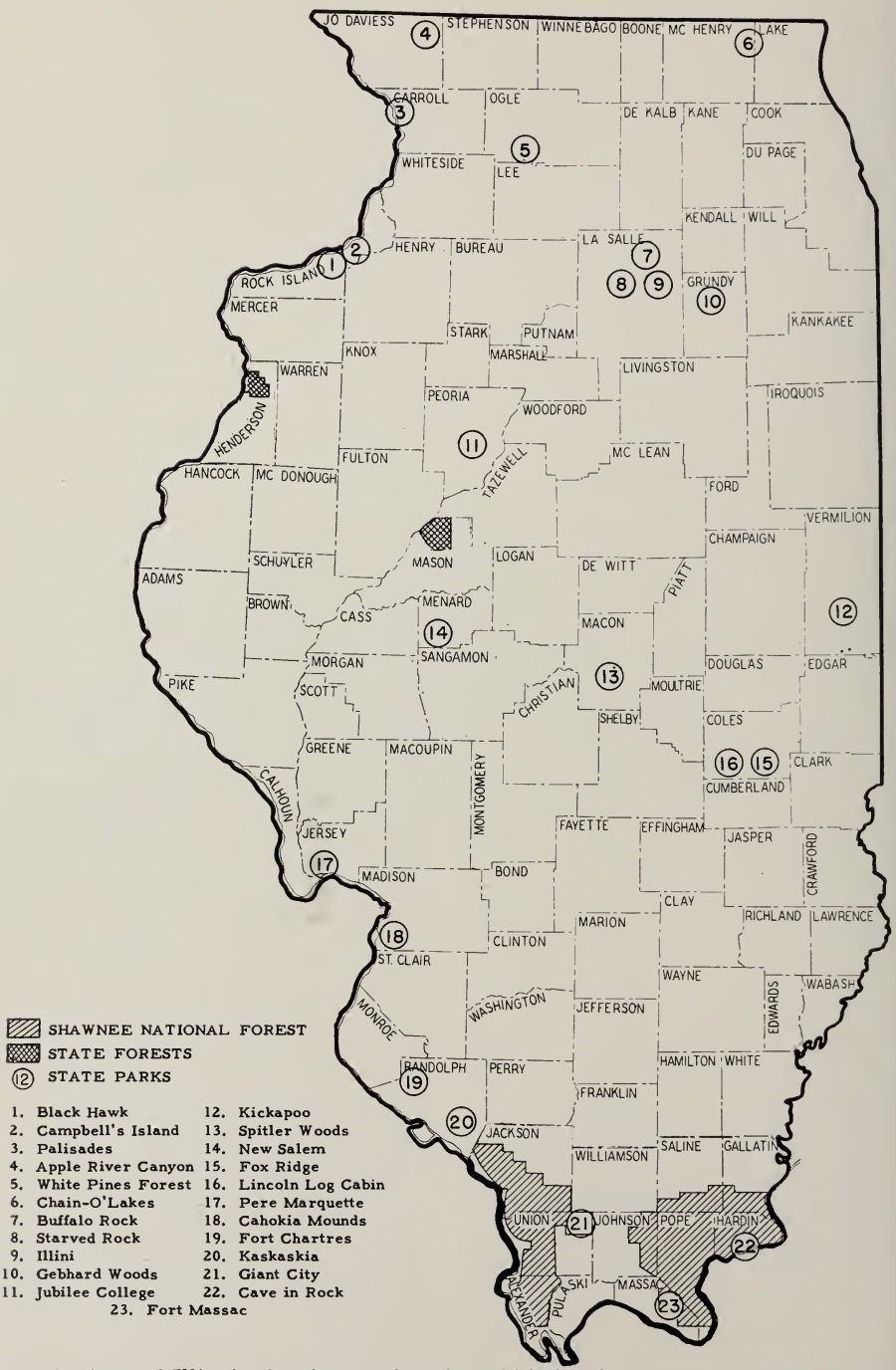

FIG. 1.—Map of Illinois showing the location of National Forests, State Forests and State Parks. (Information obtained from 1945 Official Highway Map of Illinois.)

Areas of exceptional beauty and scientific interest should be set aside for the use of all the people of the State by creating and guarding State Parks and Monuments (fig. 1).

Conservation of natural resources is a huge field of great national import, and its advancement depends upon the cooperation of everyone. But whole-hearted cooperation is impossible unless the people of the nation are aware of the conservation problems and practices.

As emphasized by all conservation organizations, private or public, for wildlife, tree, soil, or National Park conservation, the most favorable method to promote the conservation movement and to acquaint people of the problems and practices of conservation is through education. The schools of the nation provide the best media by which to spread this information; they are the educational organs of the country.

It is the privilege of every student to know the principles of conservation, the agencies trying to promote them and the results obtained through correct conservation practices. The students of today, who will be the nations leaders tomorrow, should be at least exposed to a general course in conservation of natural resources some time during their training. These leaders will have a more understanding background and will be better equipped to serve the country. They should at least know the seriousness of sediment control in streams (fig. 2), requirements and problems of the National Forests, and the type of control necessary over strategic minerals. But the leaders cannot advise or lead unless the people of the nation are themselves acquainted with the subject of conservation of natural resources.

This learning is becoming more widespread every year but it is still in its infancy. Many groups are interested in conservation and have vigorous campaigns of education, but none of these groups reach as many people as do the schools. It is true that the sportsmen of the country realized very early the problem of conservation of wildlife and have succeeded to a remarkable degree in developing wildlife conservation through private organizations and public bureaus.

It was not until 1910 when C. R. Van Hise published a volume entitled "Conservation of Natural Resources in the United States"[1] was there a popular presentation of the subject. "For the first time this all important topic was presented to the general public in such a clear and concise manner that its true significance could be grasped."[2]

Since that year only a few similar books have been written. It is true however that much has been written on the various separate phases of conservation in the last decade.

The State of Illinois has done much in the promotion of conservation of natural resources. Much was done prior to 1925 by the various branches of the State government, but it was in that year that the Department of Conservation was created and the State's efforts in conservation were unified. A brief summary of the rights, powers, and duties of the present department is as follows:[3]

Fig. 2.—Testing the suspended sediment content of the Galena River. The study of stream transported sediment is very important in soil conservation and in deciding the efficiency of such engineering structures as dams, and irrigation ditches.

1. To administer the Fish and Game Code of Illinois.
2. To take all necessary measures for the conservation, preservation, distribution, introduction, propagation, and restoration of fishes, frogs, mussels, turtles, game, wild animals, wild fowls, birds, and forests.
3. To promote and encourage hunting, fishing, and forestry in the State.
4. To take necessary measures for the investigation and prevention of pollution of the waters of the State and to work in conjunction with other departments to this end.
5. To collect, publish, and disseminate statistics and information relating to these natural assets of the State, the activities of the Department, and the industries affected by conservation and propagation.

The Illinois Natural History Survey is another State body which is important in promoting conservation in Illinois. Its work dates back many years before the formation of its sister body, the Department of Conservation.

Another state-wide group which acts in the interest of conservation of natural resources is the Committee on Conservation of the Illinois State Academy of Science. Many conservation improvements have been brought about by the power of this group.

The Department of Conservation of the State of Illinois has had summer instruction in conservation of natural resources for several years. During the summer of 1945, in their school at Lake Villa, Illinois, two 2-week courses were given to high school students and one 2-week

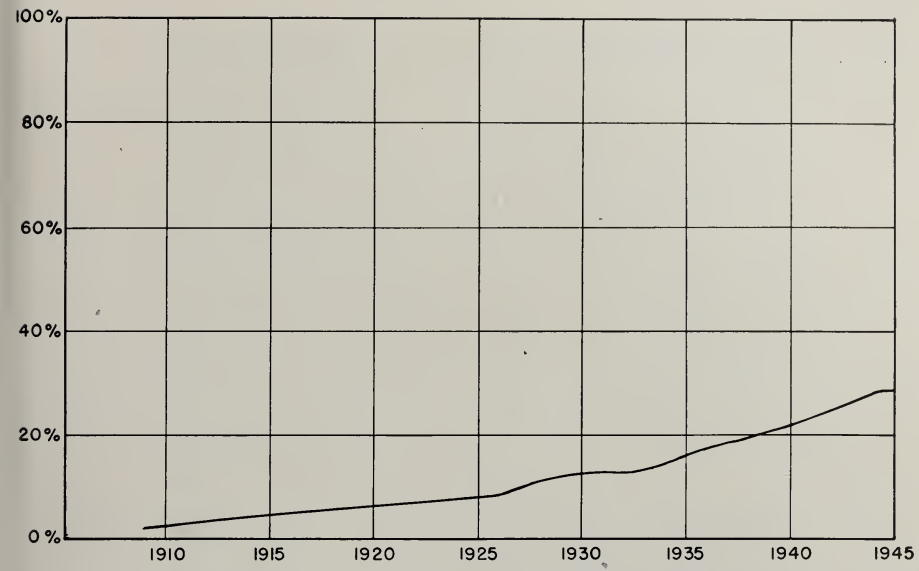

Fig. 3.—Growth of the adoption of a general course of conservation of natural resources by Illinois four-year colleges and universities.

course was given to high school teachers throughout the State.

Although this is very gratifying, this effort does not contact a large group and the courses cannot be very detailed in such a short time. The answer to the question of how to inform the people of the vital import of national and state conservation of natural resources is through the schools.

Students of college age are mature enough to grasp the gravity of conservation problems, and therefore the colleges and universities are the ideal media by which to promote conservation education. The introduction of courses dealing entirely with conservation has been tried in some Illinois high schools but as yet without much success. Perhaps the only school, or at least one of the few, offering a conservation course as such to high school students is the University High School at Carbondale, Illinois.[4]

In a recent article by V. L. Nickell,[5] Superintendent of Public Instruction in Illinois, it is revealed the State has a broad program underway to promote conservation education in the elementary and high schools of Illinois.

Survey of Illinois Colleges and Universities

According to the listing of Illinois Colleges and Universities in the 1944 Bulletin of Accredited Higher Institutions[6] as published by the United States Office of Education, there are 84 such institutions of higher learning in Illinois.

Of these listed, many are art, music, theological or aeronautical schools and are therefore not included in this survey. After excluding these types of institutions, there

remains 69 schools; 24 junior colleges and 45 four-year schools and universities. To each was sent a questionnaire requesting information about the courses offered in the field of conservation of natural resources. The following questions were asked both of the general liberal arts course in conservation and of the advanced conservation course: 1. Name of the course, 2. the date of initiation, 3. how often the course is offered, 4. the number of meetings per week, and 5. the general content and enrollment.

Returns were noted from 52 of the 69 institutions listed. In the event an institution did not return the inquiry, information concerning courses at this school was gleaned from its bulletin or register. Information gained this way probably was not as complete as that from the mailed blank.

The general course.—The most important purpose of the survey was to note the adoption of the general conservation course in the liberal arts curriculum. Such a course is defined as one of at least a semester or quarter in length and devoted entirely to the study of conservation of natural resources such as soil, water, forests, minerals, wild life, etc. This is the course which is open to all of the students and is the most important one in promoting conservation. The advanced courses are for those deeply interested in the subject; such courses do not touch a fraction of the number of students that the undergraduate general course does. It is in this elementary course that the student is introduced to the problems, practices, and importance of conservation. Also he then becomes aware that many people are in the conservation endeavor and various societies have been organized in the concern of one phase or another of conservation.

It is true that the subject of conservation of natural resources is briefly mentioned in some courses in geology, biology, geography and economics; but in such a course the matter is treated only as a side issue and its true importance is probably not emphasized. A student would have to take various courses and glean from each a small learning of conservation to attain a fair background of the subject—a background that is very necessary and that can be supplied by taking a good general course in conservation.

According to the data compiled from the returned questionnaires, the earliest any such general conservation course was taught in an Illinois college or university was in 1909 at the University of Chicago. Some state teachers colleges also adopted it quite early. It is revealed that 13 schools or 28 percent of the four-year colleges and universities included in the survey actually have a general conservation course in this curriculum (table 1). None of the junior colleges reported offer such a course; if a computation were made including the junior colleges, the percentage of institutions of higher learning in Illinois offering a course in conservation of natural resources would be 18 percent. An alarmingly low figure! Even if the junior colleges are excluded, the figure of 28 percent is still very low.

The survey reveals that most of the schools have not yet realized the importance of the subject and there-

FIG. 4.—Lower dell of Mattheissen State Park Nature Area in LaSalle County near Oglesby. The State has set this area aside as a nature preserve and wildlife sanctuary where the plant and animal life of Illinois may be saved for all time.

fore have not initiated such a general course. But such a nationally important topic, which is becoming increasingly more important as time goes on and which was brought before the public in many ways during the war, cannot be ignored. More schools are adopting such a course every year. The growth of the adoption of a general course of conservation of natural resources by Illinois four-year colleges and universities is given in figure 3. The youth of today must be informed of the importance and necessity of conserving our natural resources or the citizens of tomorrow will live in a depleted world. Future generations should not be forced to live in a world almost void of natural resources because the present citizens are ignorant of conservation problems.

The fact that almost all colleges formally listed as "Teachers Colleges" have adopted the general course is very encouraging. Future teachers with the advantage of having had such a course in conservation, will be likely to urge the adoption of such a course into the curriculum of the school at which they may later teach. In addition to being offered in the regular curriculum, it may be stated that the general course is also offered in the summer session and as an extension course at one or two of the schools.

According to census of opinion, twelve of the thirteen schools offering the general course have placed it

Table 1.—Accredited Higher Institutions in Illinois Offering Courses in Conservaton of Natural Resources (1945)

School	Offers a general course	When initiated	Offers advanced work
University of Chicago, Chicago	x	1909	x
Illinois State Normal University, Normal	x	1914	x
Northern Illinois State Teachers College, DeKalb	x	1920	
Northwestern University, Evanston	x	1927	x
Western Illinois State Teachers College, Macomb	x	1928	
The Principia College, Elsah	x	1933	
Eastern Illinois State Teachers College, Charleston	x	1935	
Southern Illinois Normal University, Carbondale	x	1936	x
Rosary College, River Forest	x	1938	
Augustana College, Rock Island	x	1940	
Concordia Teachers College, River Forest	x	1943	
McKendree College, Lebanon	x	1943	x
Chicago Teachers College, Chicago	x	1944	
University of Illinois, Urbana			x

under the supervision of the department of geography or its equivalent.

The advanced courses.—Advanced courses in conservation are here defined as those which devote all their time to only one phase of conservation and cover it quite thoroughly in a semester or two. These courses are to be generally found only in the larger universities and are attended by students seriously interested in soil, forest, wildlife, etc., conservation and probably plan to make it, directly or indirectly, their livelihood. These courses generally have certain prerequisites which keep the subject from the undergraduate student body.

Six schools gave indication that the study of conservation of natural resources is carried beyond the general course. The University of Illinois, one of the largest schools in the nation, offers advanced training in soil conservation in the Agricultural School; a course in forestry is offered in the Liberal Arts School; and a general study of the conservation of wildlife is listed but is open to only advanced zoology students. As far as known, the only course in "Methods and Problems in Conservation" offered in an Illinois school is the one scheduled at Southern Illinois Normal University at Carbondale.

Another factor to consider when discussing a school course is the student attendance. Most of the colleges list 20 to 30 as the approximate pre-war size of the general conservation classes; the universities list slightly larger classes. These figures are perhaps average for elective courses in the various schools, maybe slightly below average. The only way to influence more students is to make the course a required one. It should not be listed as fulfilling the science requirement nor should it be placed as a substitute for another subject. Need it be listed as a substitute for anything? Surely a subject so important as the future of a nation and

how to insure it should rank high on the list of subjects "required to know" or subjects needed for a liberal education.

If the upward trend toward conservation through education continues, and surely it will, more educators will awaken to its importance and in the end perhaps require that at least a general course in conservation of natural resources be taken by every student.

Illinois, with its tremendous wealth of natural resources (fig. 4) and its wonderful colleges and universities, should be one of the leading states in education of conservation of natural resources. The students of the nation should be taught the importance of conservation of natural resources by being required to take at least a general course during their college days. It is the educators duty to see that the youth is informed of the importance of conservation to insure our national heritage for future generations.

Conclusions

1. Twenty-eight percent of the four-year colleges and universities of Illinois offer the student a chance to become aware of the importance of conservation by offering a general course in conservation of natural resources.

2. As far as known, no junior college in Illinois offers such a course.

3. Six Illinois schools offer advanced work in conservation of natural resources.

Acknowledgment

The author wishes to express his appreciation to all the persons who took time from their busy schedules to submit data concerning conservation courses at their respective schools. Figure 2 is reproduced through the courtesy of the Rock Island Office of the United States Army Engineers, and 4 through the courtesy of the Illinois Department of Conservation. The drafting was done by Mr. Nelson and Mr. Engeland.

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LAKE MICHIGAN PORTS: A CLASSIFICATION BY ITEMS OF TRAFFIC

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Because ports are transfer points between two methods of transportation, the materials which are handled by a port can be indicative of the activities of a port city and its hinterland. For example, the iron ore shipped from Escanaba reveals the great mining activities nearby. Also, the variety of items which flow through a port can indicate the value of the waterside position to the economy of the port city. That these statements are true would hardly be denied, yet literature is lacking in methods of indicating the functional value of a port to its port city and hinterland.[1] As a step in this direction, this paper presents quantitative criteria for the classification of ports by items of traffic, and a classification of Lake Michigan ports based on that method. It is hoped that later studies may expand this idea and a contribution to the methodology of geography will result.

Method

The criteria for classification are derived from a study of the port statistics published yearly by the War Department.[2] To facilitate comparisons, the data for the principal items of traffic were reduced to percentages of the total traffic of the port and these percentages form the basis for the classification (table 1). Many of the ports can be classified easily on this basis, but borderline cases exist, especially among the larger ports which tend to have a greater variety of traffic than do smaller ports. However, large volume is no indication of great variety; the fifth largest port in volume of tonnage has 94 percent of its traffic confined to one item.

In reducing the principal items of traffic to percentages of the total traffic, items of like origin or related use such as sand, stone, and gravel, or gasoline and fuel oils created a problem. In order to classify a port in a category representative of its traffic, these items of like origin or related use have been combined and treated as one item. Another problem has been the variety of items carried on the cars in car ferries. In all instances, the variety has been wide, and as the car ferries are essentially extensions of rail lines and no indication of the destination of the cars can be obtained from the statistics, a category of car ferry ports has been established to obviate classifying ports as General ports when they are merely shipping and receiving points for loaded cars.

[1] Several authors have discussed the value of ports to cities and the relation of ports to hinterlands, but have not attempted to evaluate, by quantitative measurements, the classification of ports. See especially E. Van Cleef, Trade Centers and Trade Routes: D. Appleton-Century Co., Inc., New York, 1937, pp. 106-138; W. D. Jones and D. S. Whittlesey, An Introduction to Economic Geography: University of Chicago Press, Chicago, 1925, pp. 347-358; J. R. Smith and M. O. Phillips, Industrial and Commercial Geography: Henry Holt and Company, New York, 3rd ed., 1946, pp. 755-780.

[2] U. S. War Department, Annual Report of the Chief of Engineers: Government Printing Office, Washington, annual.

Table 1.—Criteria of Classification

Specialty ports (S):	Ports with more than 80 percent of traffic confined to one item, and no other item constituting 5 percent of the total traffic.
Subtype (r):	Receiving port.
Subtype (s):	Shipping port.
Combination ports (C):	Ports at which not more than three items, each of which is at least 10 percent of the total, constitute 80 percent or more of the traffic.
General ports (G):	Ports at which no three items constitute as much as 80 percent of the total traffic.

Classification

In the classification, three principal types of ports have been recognized and each type has been designated by a letter (table 1). The two subtypes are applicable only to the Specialty ports, indicating the port's function as a shipping or receiving port.

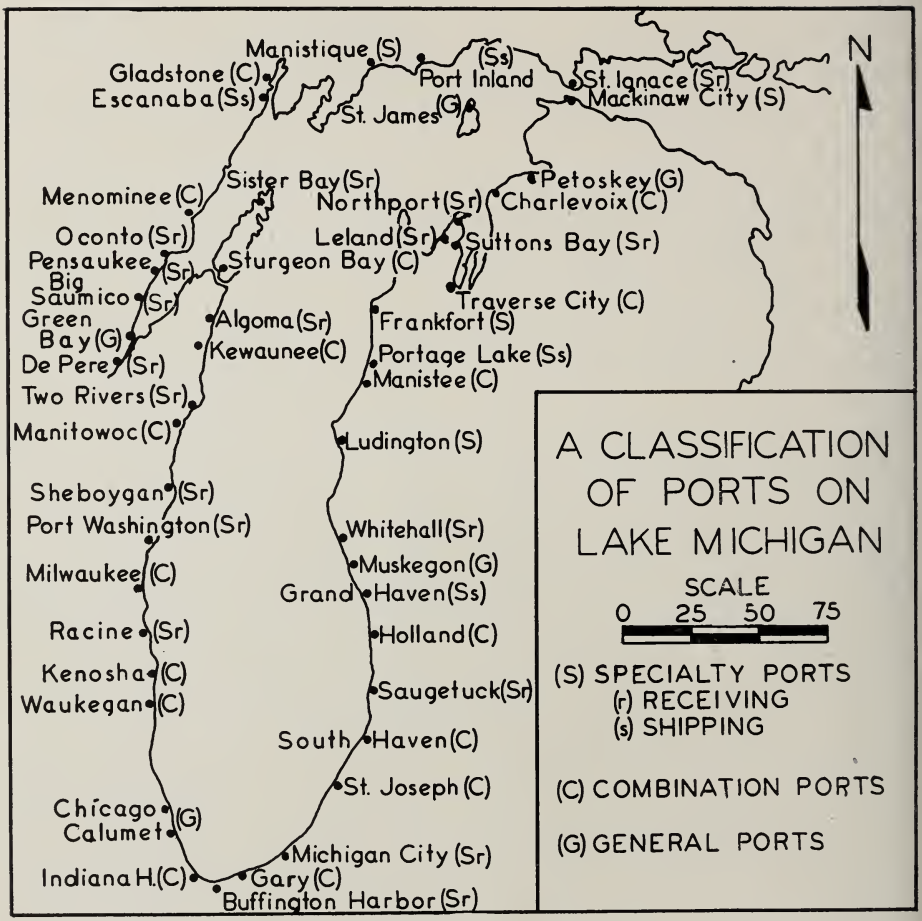
Specialty ports.—Specialty ports are the most numerous type, comprising 57 percent of the total ports on the lake (figure 1). In view of the different functions of shipping and receiving ports to the port city and hinterland, subtypes have been adopted according to whether a port receives or ships the specialty item. Car Ferry ports are excluded from the subtype classification because of the cross-haul nature of their traffic.

There are six different items of traffic which are handled by specialty ports. Coal, the item found most frequently in port statistics of Lake Michigan cities, accounts for classification of nine ports as Specialty Receiving ports (St. Ignace, Sister Bay, Two Rivers, Suttons Bay, Algoma, DePere, Port Washington, Racine and Sheboygan). Since the cost of trans-shipping coal inland from the lake shore raises the cost prohibitively as a source of heat and power, further study of the activities of these port cities will probably indicate a special industry based on the use of power. This is known to be true in at least one city, Port Washington, which has a large steam-electric generating station based on imported coal.

The second most important in number are the fishing ports, all of which are small in tonnage handled. Six ports have their entire traffic confined to the receipt of fish (Big Saumico, Michigan City, Oconto, Pensaukee, Saugetuck, and Whitehall). Car ferry ports are third most important in the number of ports classified as Specialty ports (Frankfort, Kewaunee, Ludington, Mackinaw City, and Manistique). They are both shipping and receiving ports, as befits the type of traffic they handle.

Stone ports are the fourth most important of the Specialty ports, with four devoted to shipping of the item (Buffington Harbor, Grand Haven, Port Inland, and Portage Lake). Two fresh fruit receiving ports (Leland and Northport) and one iron ore shipping port (Escanaba) make up the remainder of the specialty classification.

Combination ports.—In Combination ports the items of traffic are diverse, and yet the variety of items shipped or received at any one port indicates a concentration either in a few types of activities at the port city or the relative unimportance of waterside location to the city in the shipping and receiving of its products. It was not found practical to use the sub-classifications of shipping



and receiving ports in this category because the items of traffic in some cases were both received and shipped.

Fuels ports, handling coal and petroleum products, are the most numerous of the Combination ports, with four examples (Charlevoix, Gladstone, Holland, and Traverse City) followed closely by coal and stone ports with three examples (Kenosha, South Haven, and Manistee). Only two other ports of this classification handle the same types of items—Menominee and Manitowoc are both classified as car ferry, stone and coal ports. The other six ports classed as Combination ports are individual in the combination of items handled: iron ore, stone and coal (Gary); car ferry, coal, and petroleum products (Milwaukee); stone, coal, and petroleum products (St. Joseph); car ferry, stone, and petroleum products (Sturgeon Bay); iron ore, coal, and petroleum products (Indiana Harbor); and coal and steel billets (Waukegan).

General ports.—The five remaining ports on Lake Michigan for

which data are available are General ports (Chicago-Calumet, Green Bay, Petosky, St. James, and Muskegon). Each has a high percentage of its traffic confined to a few items, but a wide variety makes up the remainder of their traffic. Two of these ports (St. James and Petosky) are small in total tonnage handled, and it is felt that both of these would be in a more specialized classification if more detailed statistics on them were available. The other three ports are truly General ports, receiving and shipping a wide variety of goods.

Distribution of Ports

The map of Lake Michigan ports shows that few ports are closer than ten miles apart and that there are few stretches of shore line of more than fifty miles without a port. Around the lake from St. Ignace to Mackinaw City the midpoint in the number of ports is reached between Chicago and Waukegan. The line dividing the ports on the northern half of the lake from those on the southern half crosses the lake from north of Kewaunee on the western shore to south of Portage Lake on the eastern side.

General ports are more or less evenly spaced around the lake. They are located at the head of Green Bay, the south end of Lake Michigan, in the middle and at the north end of the eastern shore, and on Beaver Island—situations, except for the last named, from which they serve a wide hinterland. The position of Milwaukee between the general ports of Chicago and Green Bay, with their overlapping hinterlands, helps to explain the puzzling lack of variety in its items of trade.

In contrast to the even distribution of the General ports is the concentration of the Specialty and Combination ports. Of the twenty-four ports which are located in the northern part of the lake, exactly two-thirds are Specialty ports. This is 9 percent more than the average for the lake as a whole. Among these northern Specialty ports are the two fruit ports, the iron ore port, four of the six fishing ports, five of the nine coal ports, two of the five car ferry ports, and one of the four stone ports.

Whereas the Specialty ports are concentrated on the northern part of the lake, a similar concentration of Combination ports is apparent in the southern part of the lake. Here are located two-thirds of the ports so classified. None of the ten Combination ports in the southern part of the lake has the same combination of items of trade, whereas three of the five ports classified in this category in the northern part of the lake are fuel ports—indicative, perhaps, of the broader economic base of the southern port cities or of larger hinterlands served by them.

Conclusions

The classification of ports on the basis of the number of items of trade into Specialty, Combination, and General ports presents a basis for the investigation and comparison of port cities and their hinterlands. It is not felt that this method should be an end product in itself, nor that the entire picture of a port's function can be obtained by this classification. However, the method recommends itself, by directing attention through the items of traffic, to activities of the port city or its hinterland.

GEOLOGY

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1. Structural Trends in the Pecatonica Quadrangle Based upon Decorah Stratigraphy: Charles L. Bieber, North Central College, Naperville. (slides)

2. Some Chester Outcrops and Subsurface Sections in Southeastern Illinois: Elwood Atherton, Illinois State Geological Survey, Urbana. (slides)

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8. Unusual Oolite Grains from the Ste. Genevieve Limestone: Raymond S. Shrode, Illinois State Geological Survey, Urbana. (slides)

* 9. Observations on Temperature of Formation of Illinois Fluorite: R. M. Grogan, Illinois State Geological Survey, Urbana. (slides)

*10. A Study of the Refractive Indices of Opaque Isometric Minerals: M. Darwin Quigley, Northwestern University, Evanston. (slides)

11. A Spectrographic Check on the Petrographic Method: Carleton A. Chapman and Geo. K. Schweitzer, University of Illinois, Urbana. (slides)

*12. Geological Applications of the Ionic Potential: Geo. K. Schweitzer and Carleton A. Chapman, University of Illinois, Urbana. (slides)

*13. A Summary of Philippine Geology: H. L. Patton, University of Illinois, Urbana.

*14. A Rockslide in the Snake River Range, Wyoming: William A. Oesterling, University of Illinois, Urbana. (slides)

*15. The Distribution of Zircons in the Tuscaloosa Formation of North Carolina: Walter R. Ziebell, University of Illinois, Urbana. (slides)

*16. A Treatment of the Effects of Hole Caving upon Resistivity Curves of Electric Logs: William E. McCommons, University of Illinois, Urbana (Read by title.)

*Not published.

SOME CHESTER OUTCROP AND SUBSURFACE SECTIONS IN SOUTHEASTERN ILLINOIS[1]

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Introduction

This paper is intended to aid studies of the Chester series by presenting electric logs of several formations alongside the descriptions of corresponding cores or outcrops, and, for the basal Chester, insoluble residue zones. For the electric logs, lithologic interpretations are shown in the central columns. For the cores and outcrops, the rocks are described in some detail. Fine dashed lines extending from the electric log to the graphic log are meant to draw attention to the similarities of succession. The locations of all wells, outcrops, and cores are shown on the index map of southeastern Illinois (fig. 1). The Chester formations illustrated include the Kinkaid, Degonia, Clore, Palestine, Menard, Golconda, and Renault (Downeys

[1] Published with permission of the Chief, Illinois State Geological Survey, Urbana, Illinois.

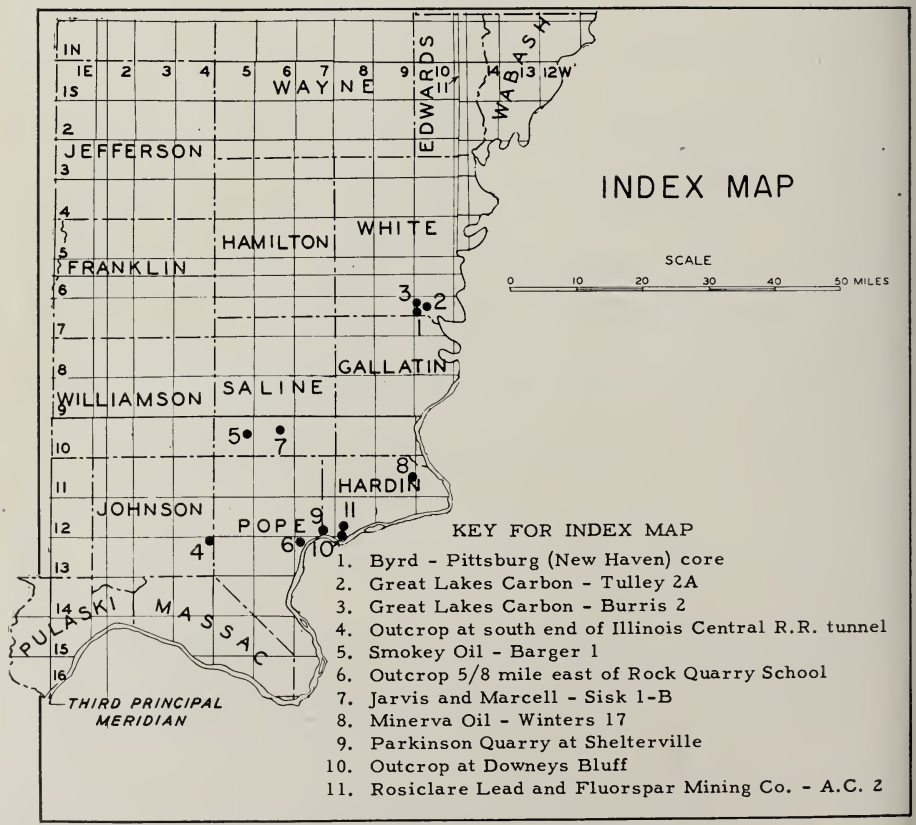


Fig. 1.—Locations of cores and outcrops

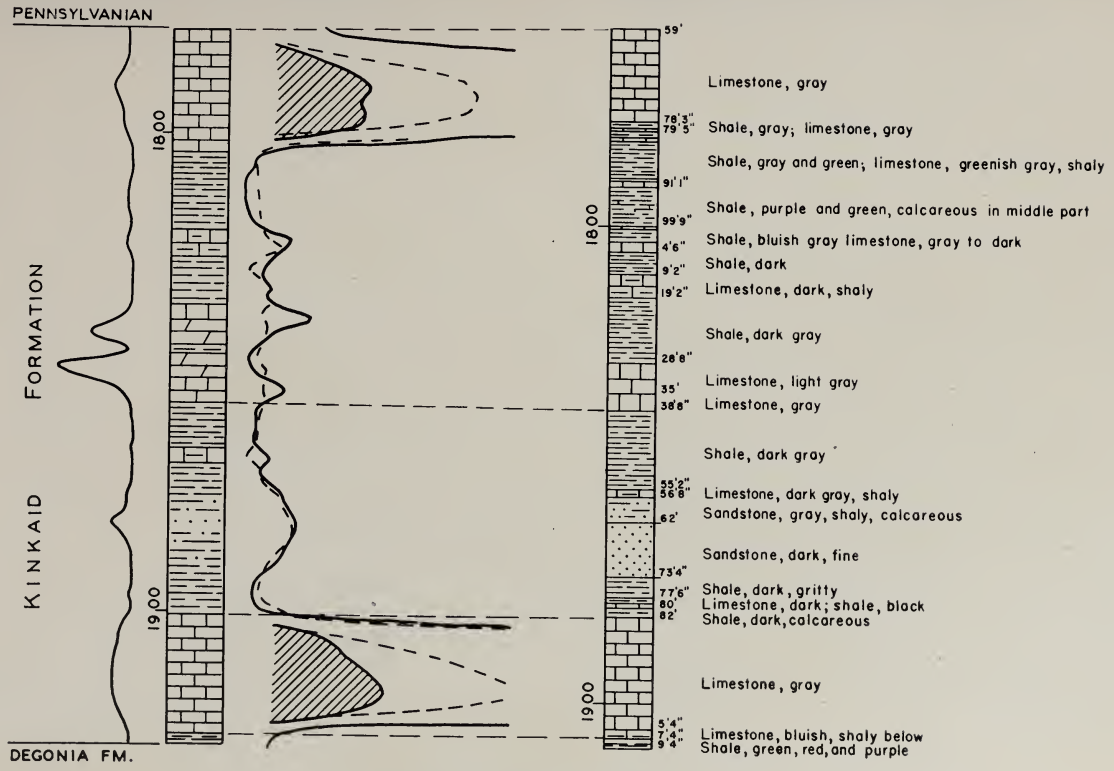


FIG. 2.—Kinkaid formation

Bluff and Shetlerville) formations.

Kinkaid Formation (Fig. 2)

The Kinkaid formation in the "New Haven" core (drilled in 1913 and described by Savage[2]) is shown graphically with the corresponding portion of the electric log of a well about 3/8 mile to the northeast.

The Kinkaid in the core is immediately overlain by Pennsylvanian sandstone and conglomerate and is underlain by the Degonia shown in fig. 3. Outstanding features of the Kinkaid in both core and electric log are the massive upper and lower limestones. The intervening portion includes some limestone in its central and sandstone in its lower part. At the base are a few feet of green, red, and purple shales.

Degonia Formation (Fig. 3)

The "New Haven" core and electric logs of nearby wells show three sandstone beds within 100 feet below the Kinkaid formation. Oil geologists in this area generally put the upper two beds in the Degonia formation, and the third bed in the Clore formation, as is done here. It is possible that when the Degonia formation is traced in detail from the type locality in western Illinois across to this area, the bounds shown here may be modified.

Clore Formation (Fig. 3)

The Clore formation in this area consists mainly of shale, shaly limestone, and sandstone. The prominent sandstone in the upper part is known to oil geologists as the "Clore sand." Commonly more green shale is encountered than is reported from the "New Haven" core.

Palestine Formation (Fig. 4)

The Palestine formation in the "New Haven" core is 105 feet thick and consists of sandstone except for about 5 feet of shale and shaly sandstone near the top, and minor shale laminae. The Palestine formation in southeastern Illinois generally is thinner than this, averaging about 55 feet, and it usually includes a larger proportion of shale.

Menard Formation (Figs. 4 and 5)

There is an unconformity below the Palestine formation, and in many parts of southeastern Illinois the Menard includes higher beds than are present in the "New Haven" core (fig. 4). The "massive Menard" occurs between the depths 2170′6″ and 2205′ in the core, and the "little Menard" between 2214′9″ and 2219′9″. The "little Menard" is often sandy in this part of the state.

Few electric logs are available near the Menard outcrop described by L. E. Workman[3] and shown in fig. 5. The formation is sufficiently uniform, however, for the electric log of the Smokey Oil-Barger No. 1 well, about 18 miles northeast of the outcrop, to show considerable similarity. Neither the upper nor the basal portions of the formation are exposed in the outcrop. The top of the "massive Menard" is at 63′11″ in the outcrop. In the well the Menard is underlain by shaly sandstone of the Waltersburg formation.

Separation of the basal Menard shale from underlying Waltersburg shale is usually difficult. Some geologists prefer to mark the base of the Menard formation by the base of the "little Menard" limestone.

Golconda Formation (Fig. 6)

The Golconda formation in south-

[2] Technical files, State Geological Survey, Urbana, Illinois.

[3] Field notes. L. E. Workman. State Geological Survey, Urbana, Illinois.

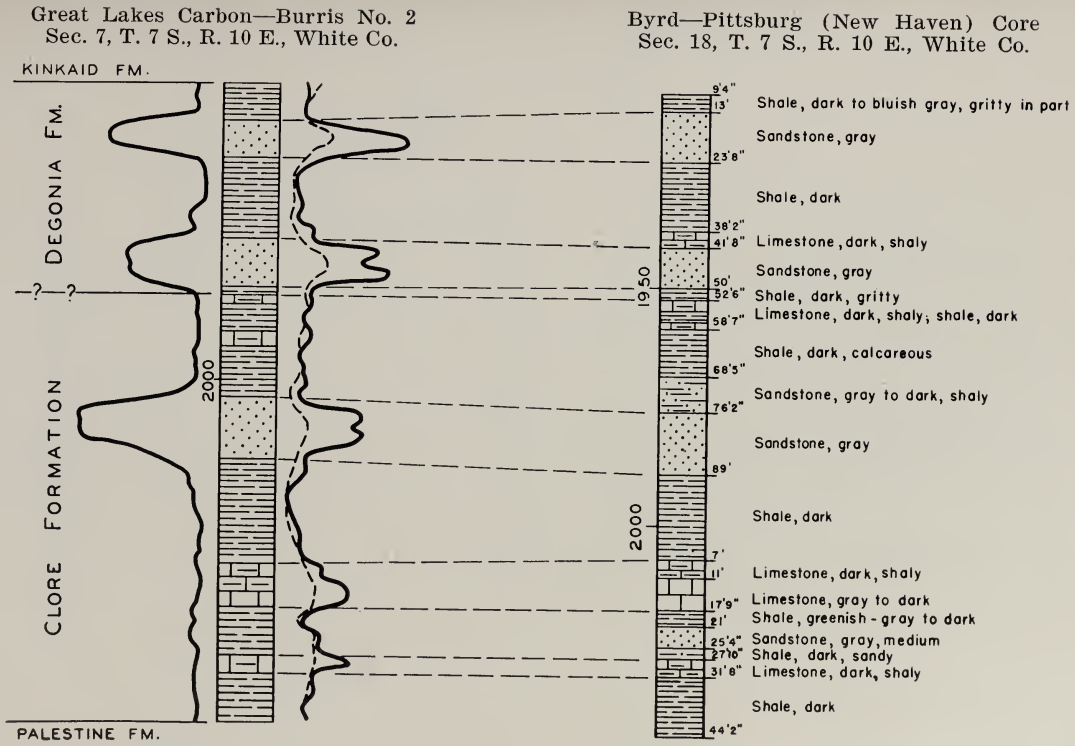
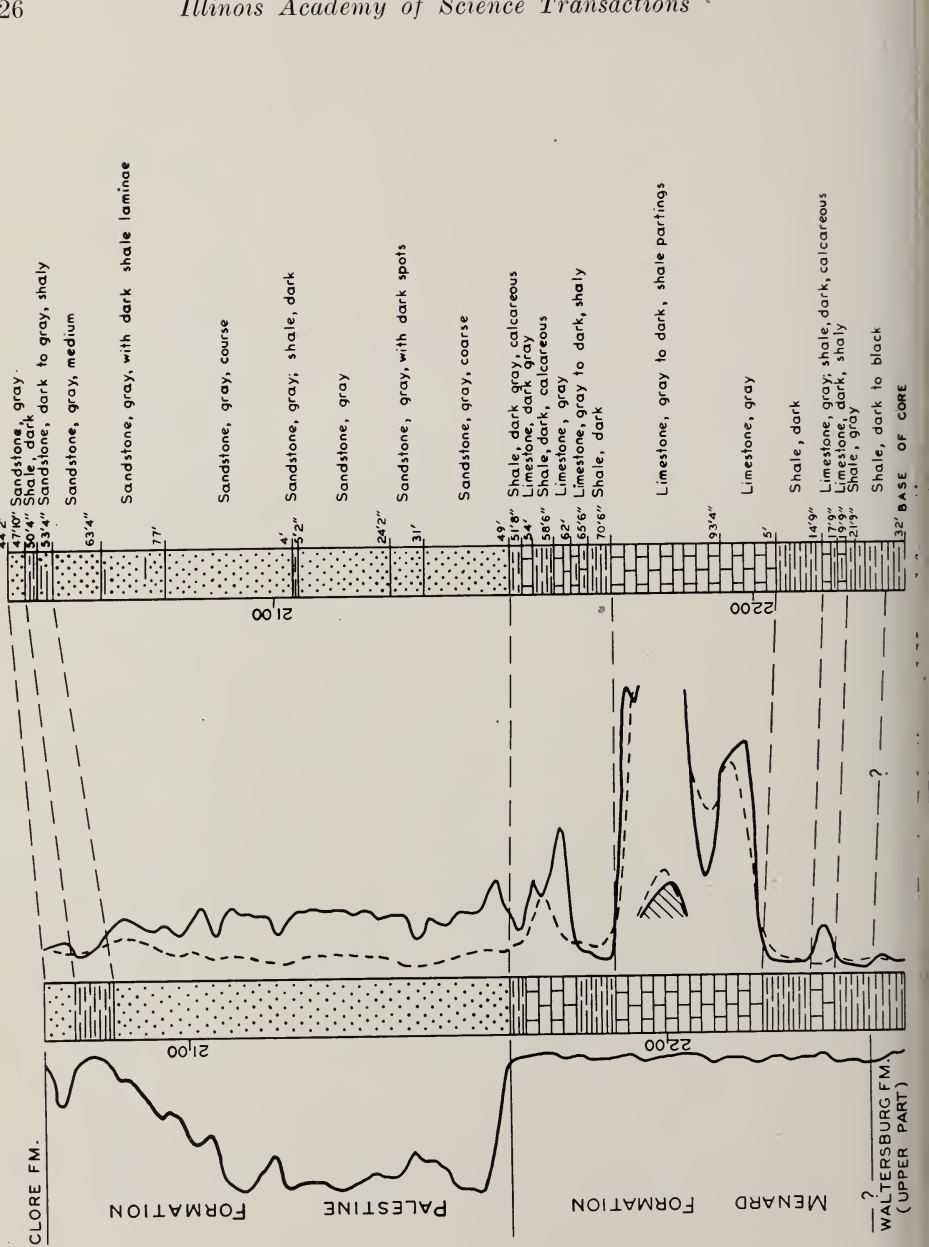


FIG. 3.—Degonia and Clore formations


Byrd—Pittsburg (New Haven) Core
Sec. 18, T. 7 S., R. 10 E., White Co.
Great Lakes Carbon—Burris No. 2
Sec. 7, T. 7 S., R. 10 E., White Co.
CLORE FM.
PALESTINE FORMATION
MENARD FORMATION
WALTERSBURG FM. (UPPER PART)
44'2" Sandstone, gray
47'10" Shale, dark
50'4" Sandstone, dark to gray, shaly
53'4" Sandstone, gray, medium
63'4" Sandstone, gray, with dark shale laminae
77' Sandstone, gray, course
4' Sandstone, gray; shale, dark
5'2" Sandstone, gray
24'2" Sandstone, gray, with dark spots
31' Sandstone, gray, coarse
49' Shale, dark gray, calcareous
51'8" Limestone, dark gray
54' Shale, dark, calcareous
58'6" Limestone, gray
62' Limestone, gray to dark, shaly
65'6" Limestone, gray to dark, shale partings
70'6" Shale, dark
93'4" Limestone, gray
5' Shale, dark
14'9" Limestone, gray; shale, dark, calcareous
17'9" Limestone, dark, shaly
19'9" Shale, gray
21'9" Shale, dark to black
32' BASE OF CORE
2100
2200

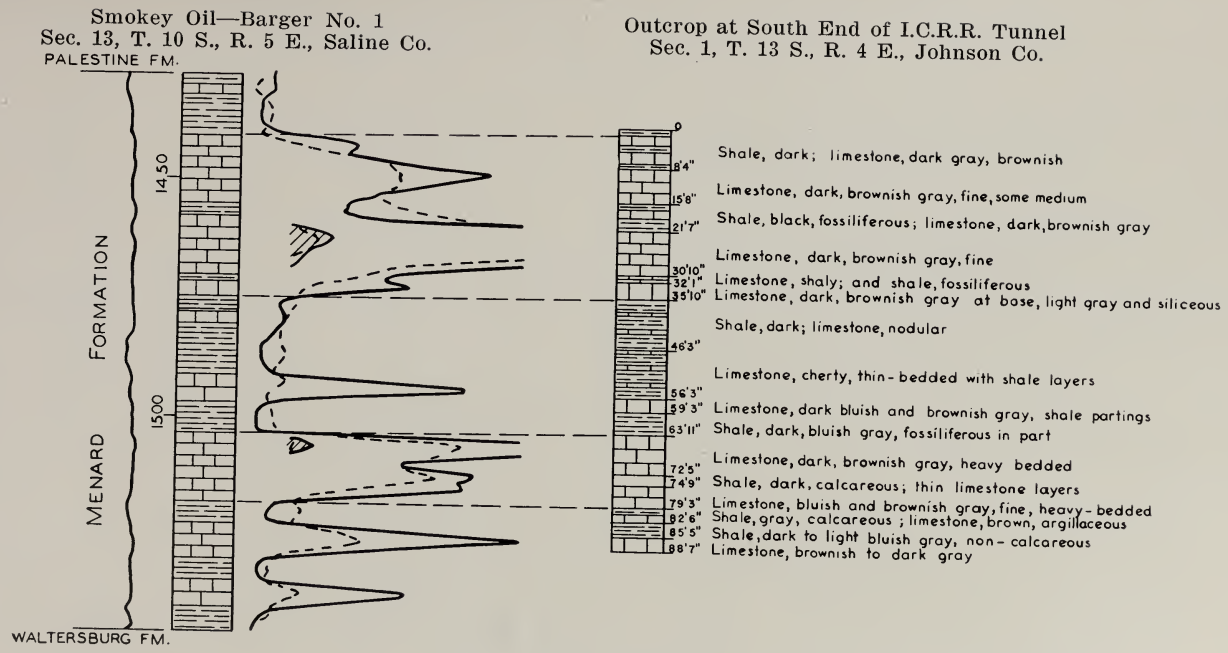
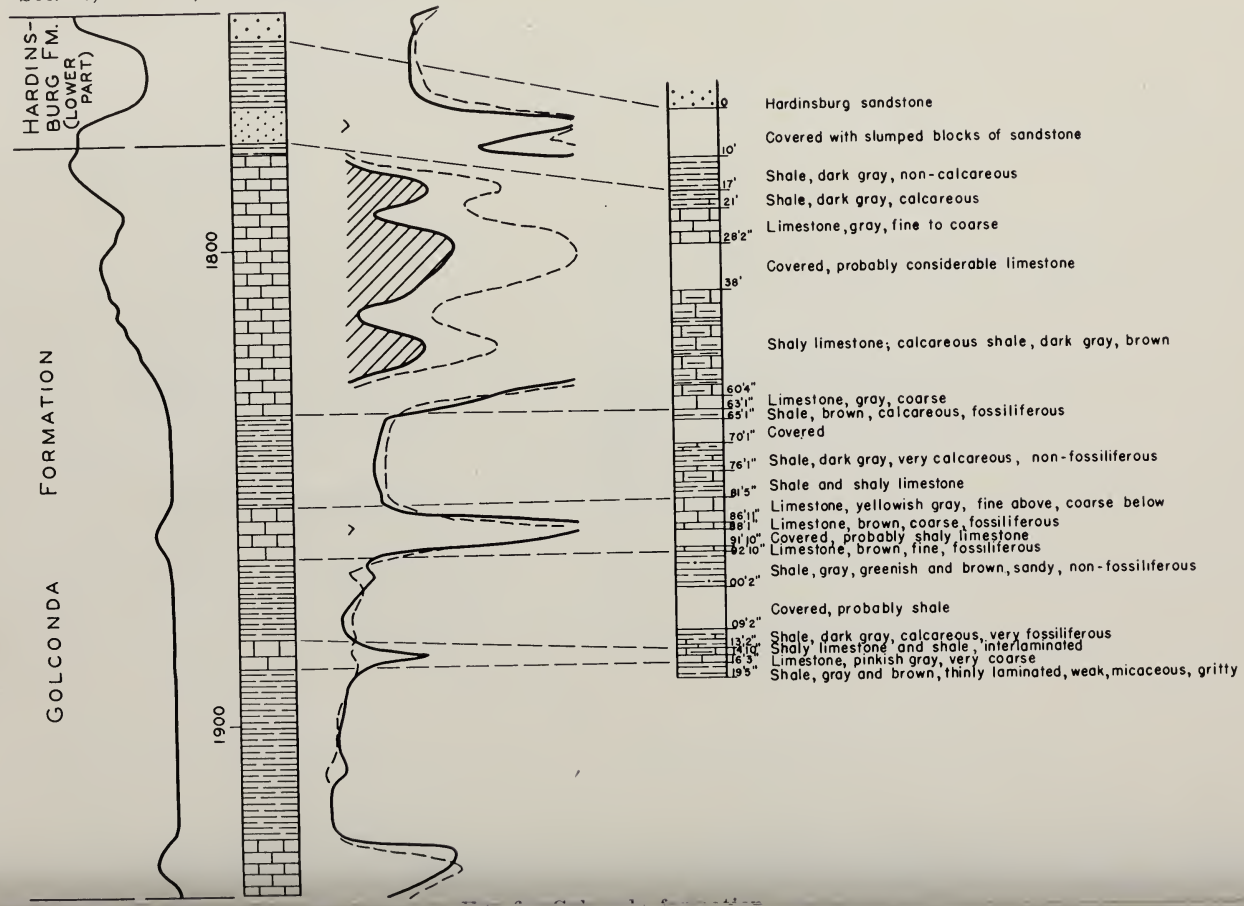


FIG. 5.—Menard formation

Jarvis Bros. and Marcell—Sisk No. 1-B
Sec. 15, T. 10 S., R. 6 E., Saline Co.

Outcrop Near Rock Quarry School
Sec. 5, T. 13 S., R. 7 E., Pope Co.



eastern Illinois typically includes at the top dark gray, red, and green shales with thin, brown, sublithographic dolomite. The bulk of the formation consists of a zone which is dominantly limestone, underlain by a zone which is dominantly shale. At the base is the "Barlow limestone," with sometimes a few feet of basal shale. The "Barlow" is a thin extensive bed, often mapped to show subsurface structure. In the sections illustrated, most of the upper shale zone was eroded before deposition of the Hardinsburg formation. The "Barlow limestone" is shown in the electric log at the base of the Golconda. Samples show that in this well the "Barlow" is immediately underlain by dark gray silty shale and sandstone of the Cypress formation. The lower part of the Golconda is not exposed in the outcrop section described by L. E. Workman.[3]

The electric log is from a well located about 17 miles north of the outcrop.

Renault (Downeys Bluff and Shetlerville) Formation (Figs. 7 and 8)

The lower part of the Chester in Hardin County has been called the Renault formation. Frank Tippie[4] correlates the upper part of the Renault with the basal Paint Creek of western Illinois, and has proposed the name "Downeys Bluff" for this member of the Paint Creek, based on the type section shown in fig. 8 and located at Downeys Bluff in NW¼, SE¼, sec. 5, T. 13 S., R. 8 E. The remainder of the Renault is here referred to as the Shetlerville member.[5]

The Downeys Bluff and Shetlerville are illustrated by an electric log (fig. 7), the outcrop section at Shetlerville[6] (fig. 7), Tippie's type section for the Downeys Bluff[4] (fig. 8), and the core[6] (fig. 8) from which he describes insoluble residue zones of the Renault formation.[7] Tippie subdivides the Renault into five zones, A to E, based on insoluble residues. These zones are shown for the core and approximated for the electric log and two outcrop sections.

In the electric log (fig. 7) it is impracticable to pick the contact of the Shetlerville on the underlying Levias member of the Ste. Genevieve formation, so the position of this contact is estimated. In the Parkinson quarry section (fig. 7), the sublithographic limestone at 15 to 18.5 feet is correlated with the sublithographic limestone at depth 223.8 feet in the core (fig. 8), and therefore is placed in the C zone of the Shetlerville formation.

Acknowledgments

Mr. A. H. Cronk, Superintendent, Rosiclare Lead and Fluorspar Mining Company, Rosiclare, Illinois, has given permission to describe the lithology of part of the core from the Rosiclare Lead and Fluorspar Mining Company—A. C. No. 2 diamond drill hole. Thanks are extended to various members of the Illinois State Geological Survey for their help.

[3] Field notes. L. E. Workman. State Geological Survey, Urbana, Illinois.

[4] F. E. Tippie, Subsurface Stratigraphy of Lower Chester Formations in Parts of Illinois and Western Kentucky. Ill. State Geol. Survey, unpublished manuscript.

[5] cf. Lexicon of Geologic Names of the U. S., U. S. G. S. Bull. 896, p. 1985.

[6] Described by F. E. Tippie, Technical files, State Geological Survey, Urbana, Ill.

[7] F. E. Tippie, Insoluble Residues of the Levias and Renault Formations in Hardin County, Illinois: Trans., Illinois State Acad. Sci., Vol. 36, No. 2, December 1943, p. 155.

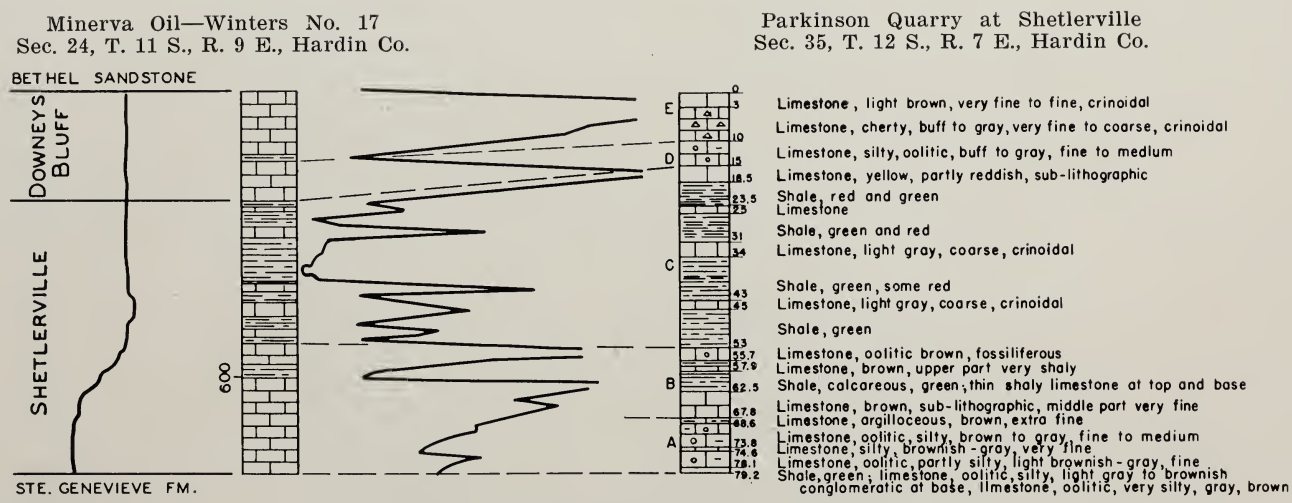


FIG. 7.—Renault (Downeys Bluff and Shetlerville) formation

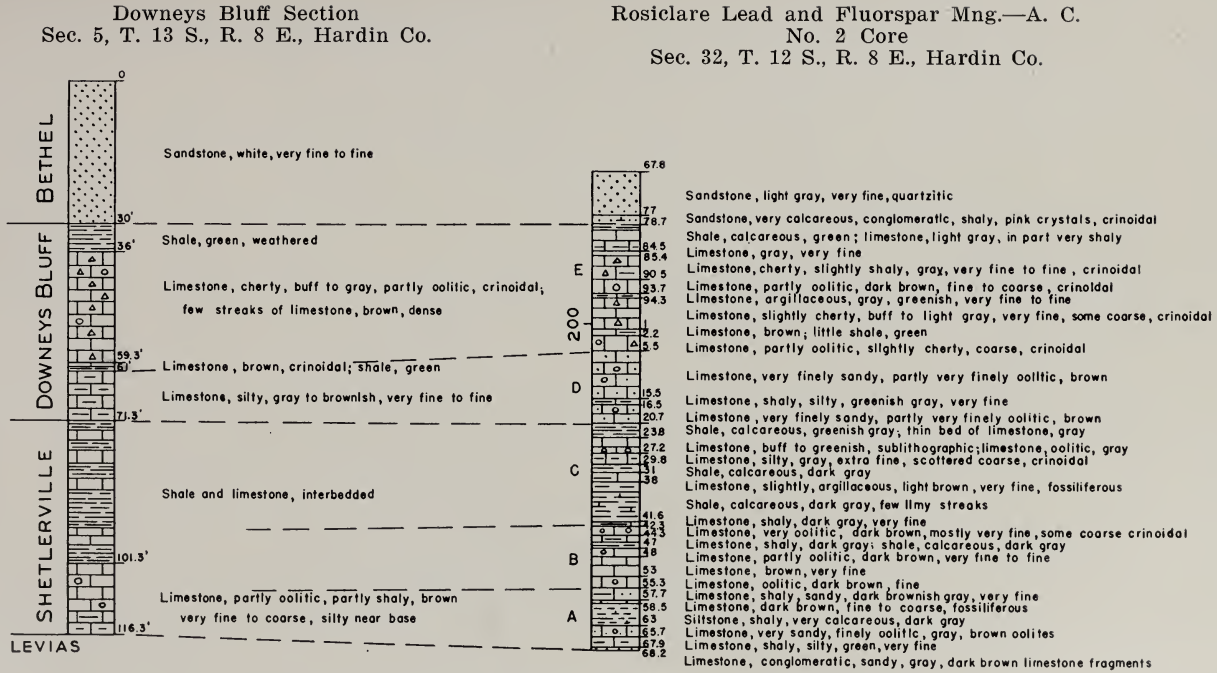


FIG. 8.—Renault (Downeys Bluff and Shelterville) formation

STRUCTURAL TRENDS IN THE PECATONICA QUADRANGLE BASED UPON DECORAH STRATIGRAPHY

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North Central College, Naperville

The Pecatonica quadrangle in northern Illinois is located on the southern flanks of the Wisconsin arch. Rock exposures are plentiful in the north half of the area where the glacial drift cover is thin. Southeastward the drift thickens and bedrock exposures are less numerous. The stratigraphic formation upon which this report is based, and upon which the structural trend map is drawn, is the relatively thin transition zone between the Platteville and Galena formations, interpreted herein as Decorah.

Rocks of Decorah age average from 10 to 20 feet thick over the crest of the Wisconsin arch in the Pecatonica quadrangle. The formation comprises thin to medium-bedded fossiliferous dolomites, interspersed sparingly with blue-green shaly partings. The lower Decorah beds consist of a greenish-blue shaly facies which is distinctive when exposed on fresh surfaces. Locally the shaly phase is absent.[1] *Sowerbyella* is commonly present in the lower Decorah beds. Zones crowded with *Dalmanella* are scattered throughout the Decorah,[2] but tend to be more plentiful upward. Ramose bryozoans are concentrated locally with the *Dalmanella* zones.

Lithologically, the upper beds of the Decorah grade into the buff-colored sugary and commonly cherty Galena (Prosser member). The Decorah-Galena contact cannot be drawn with certainty, but herein is taken to be where crowded *Dalmanella* zones cease and green shaly partings give way to the typical Galena lithology. Dwarf forms of *Receptaculites* are scattered in the transitional upper Decorah horizon.

The contact between Platteville and Decorah beds is drawn at the base of the blue-green shaly dolomite. The Spechts Ferry member of the Platteville formation is not surely recognized in the area, but may be included in the dense, buff, locally cherty beds which commonly underlie the Decorah. The Spechts Ferry member is reported in south central Wiconsin.[3] The number three and four beds of the Harrison section may represent the Spechts Ferry member. At a roadside exposure in the north part of the quadrangle in the SW.¼ SW.¼ sec. 36, T. 29 N., R. 9 E., *Pionodema subaequata* is in shaly dolomite underlying Decorah beds. In the west part of the area, upper Platteville rocks near the Decorah contact exhibit buff to brown shaly partings on wavy bedding planes.

[1] DuBois, E. P., Subsurface relations of the Maquoketa and "Trenton" formations in Illinois: Illinois Geol. Survey Rept. Inv. 105, pp. 21-23, 1945.

[2] Bays, C. A. and Raasch, G. O., Mohawkian relations in Wisconsin: Guidebook of the 9th. Ann. Field Conference Kansas Geol. Soc., p. 298, 1935.

[3] Bays, C. A. and Raasch, G. O., op. cit.

Roadside Quarry, Three Miles Southeast of Harrison, Center of Sec 36, T. 28 N., R. 11 E., Rockford Quadrangle

	Covered.	Thickness Ft.	In.
10.	Dolomite, buff, massive, cherty, sugary, weathered	6	
9.	Dolomite, buff, a few green shaly partings, weathers sugary; *Dalmanella*, bryozoans, fucoids	10	
8.	Dolomite, gray, blue-green shaly partings common, beds 2 to 10 inches thick; fucoids profuse on the bedding planes below		8
7.	Dolomite, buff, massive, a few shaly partings at top, iron stains, sparingly fossiliferous	1	6
6.	Dolomite, thin-bedded, a few blue-green shaly partings, *Dalmanella* sparing	0	8
5.	Dolomite, buff to blue, blue wavy shaly partings, fossiliferous	0	7
4.	Dolomite, buff, thin-bedded, brown shaly partings; siliceous, rotting, weathers white; fossiliferous in center with *Sowerbyella* and *Holopea*	2	2
3.	Dolomite, buff, chert common, beds 2 to 6 inches thick; a few solution pocks upward; small *Strophomenids* center	10	
2.	Dolomite, buff, massive; *Strophomena* and *Streptelasma*	2	6
1.	Dolomite, buff, thin-bedded, iron stains; fucoids, small gastropods	3	
	Base of quarry		

Roadside Exposure, Three Miles Southeast of Rock City, East Bluff of Rock Run Creek, NW.¼ NW.¼ Sec. 2, T. 27 N., R. 9 E., Pecatonica Quadrangle

	Covered.	Thickness Ft.
13.	Dolomite, buff, weathers sugary	1
12.	Dolomite, buff, a few traces of green shale, weathers sugary	7
11.	Dolomite, buff, greenish, shaly; *Dalmanella* common	1
10.	Dolomite, sugary, a few shaly partings; crinoid fragments, *Sowerbyella*, *Strophomena*, dwarf *Receptaculites* above	4
9.	Dolomite, buff, green, shaly	3
8.	Dolomite, weathers sugary; cf. *Sowerbyella*, cf. *Pionodema*	5
7.	Dolomite, partly covered, buff, beds two to six inches thick, chert sparing	8
6.	Dolomite, buff, iron-stained, thin-bedded, fucoidal	1
5.	Dolomite, buff, scattered chert; silicified *Streptelasma* and *Columnaria*; solution pocks scattered	4
4.	Dolomite, buff, cherty	1
3	.Dolomite, buff; silicified *Streptelasma* above	6
2.	Dolomite, buff, medium to fine grain; sparingly fossiliferous	3
1.	Dolomite, buff, fucoids sparing; *Strophomena*, *Streptelasma*, *Leperditia* profuse	1

Criteria found useful in determining the relative placement of Decorah strata in the area follow:

1. Zones crowded with *Dalmanella,* and scattered crinoid fragments with *Glyptorthis.*

2. An occasional dwarfed form of *Receptaculites* associated with, or a few feet above, the *Dalmanella* zones in transitional upper Decorah beds.

3. *Leperditia cf. fabulites* commonly scattered 8 to 15 feet below the *Dalmanella* zones.

4. Silicified fossils, scattered in upper Platteville, most common of which are *Columnaria* and *Streptelasma corniculum.*

5. Profuse fucoids scattered on the bedding planes mostly in the upper Platteville, but extending up into the Galena formation.

6. Blue-green shaly partings on wavy bedding planes, more common in lower Decorah strata.

7. Black and dark brown mineral specks, probably manganese, with dendrites.

8. Locally, buff to brown shaly partings in upper Platteville beds.

9. Locally, *Pionodema* underlying Decorah shales.

The base of the shaly dolomite Decorah formation can be identified at exposures with a fair degree of accuracy. The Platteville-Decorah contact is therefore used as a key horizon in mapping structural trends in the quadrangle. Outcrop elevations on the top of the Platteville, which provides most of the control, are estimated from contour maps. Use of well logs is limited because the Decorah formation is not delimited in the older wells.

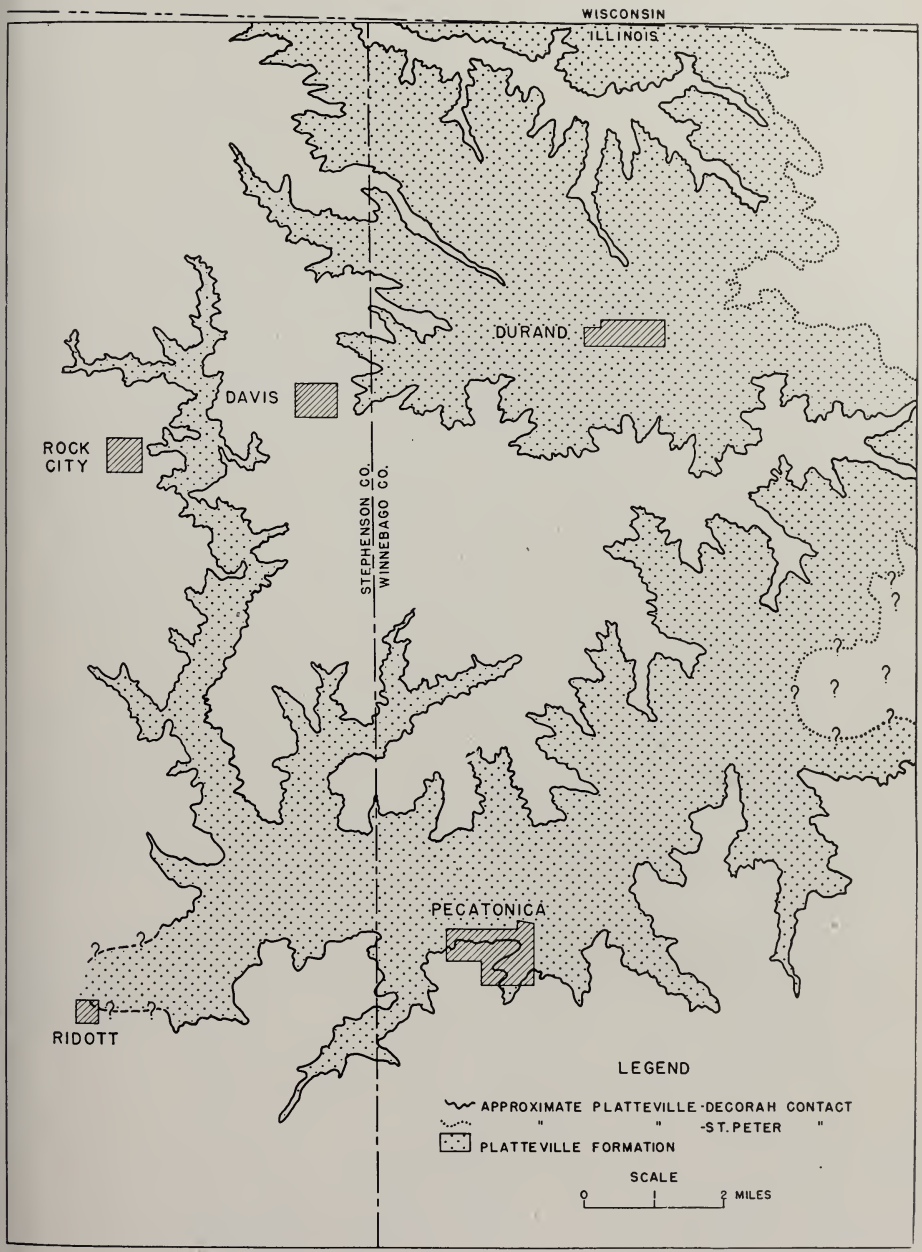
Two maps are presented. Fig. 1 shows the approximate Platteville-Decorah contact. Fig. 2 shows structural trends by contours drawn on the top of the Platteville formation.

In general, the structural trends in the area follow maps drawn on the top of the Galena.[4] The west part of the area shows a marked syncline with north-south axis, named herein the Rock Run syncline. The north center exhibits a gentle arch pitching southward at about 25 feet per mile. The axis is approximately north-south through the central part of the quadrangle and marks the south central margin of the Wisconsin arch. The village of Pecatonica is on the crest of the arch, near its southern extremity. In the extreme northeast a syncline trends northwest-southeast, the axis of which is near the village of Avon, Wisconsin. From the east-center margin of the quadrangle a small flexure pitches southeastward in the direction of Rockford. A structural sag is in the southern part of the quadrangle, whose long axis trends east-west. This feature is probably a part of structure referred to as the Ogle county line syncline.[5]

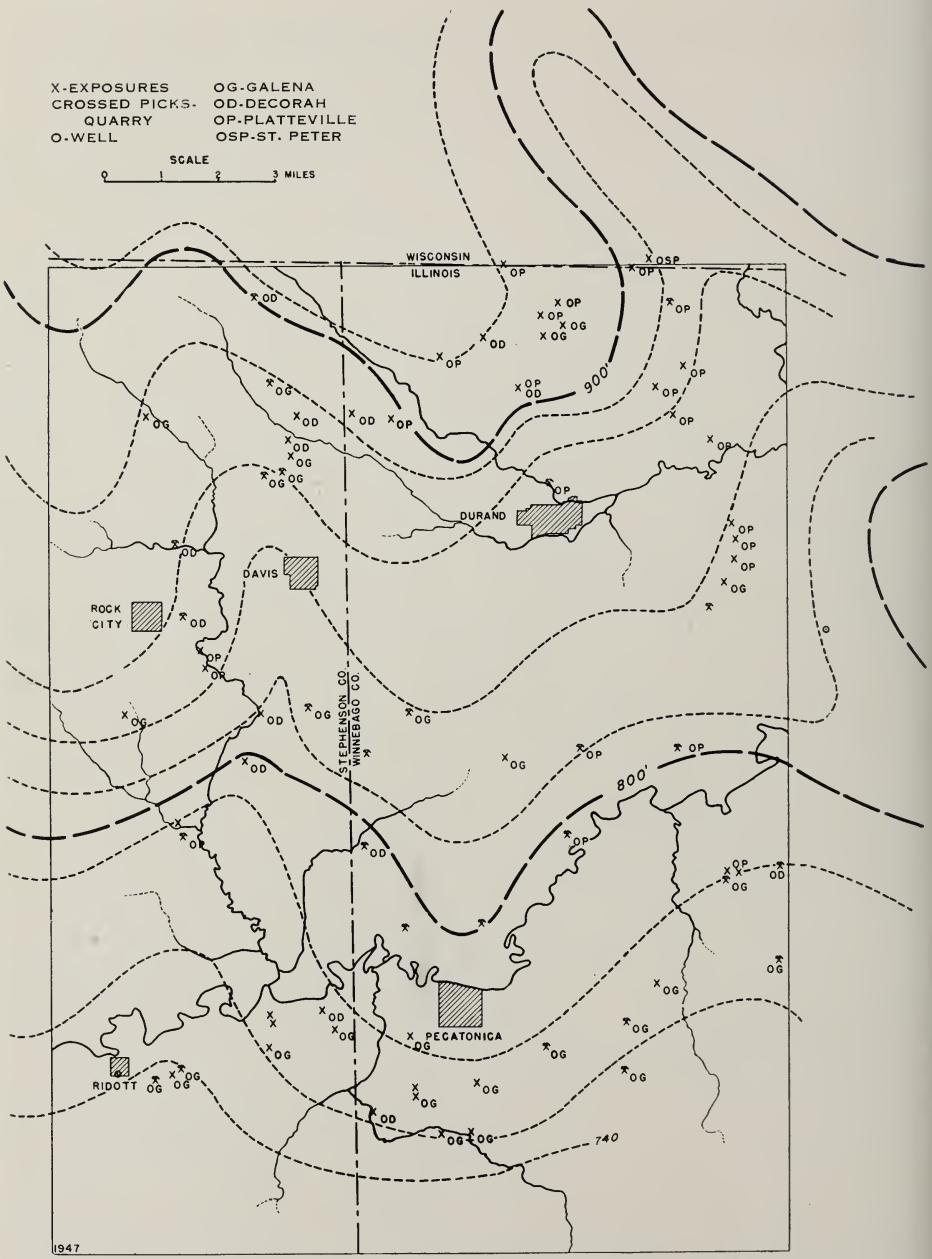
Strata exhibiting moderate dips of from 5° to 10° are at two locations: (1) Three miles southeast of Rock City, east bluff of Rock Run Creek at roadside, NW. ¼ NW. ¼ sec. 2, T. 27 N., R. 9 E., and (2) two miles south southeast of Ridott, SE. ¼ SE. ¼ SW. ¼ sec. 4, T. 26 N., R. 9 E. This latter location may represent slump in an area of solution.

[4] Horberg, Leland, Preglacial erosion surfaces in Illinois: Illinois Geol. Survey Rept. Inv. 118, p. 185, 1946.

[5] Cady, G. H., Structure of the LaSalle anticline: Illinois Geol. Survey Bull. 36, p. 132, 1920.



Generally, the area is one of gentle warping and southward pitch, in which nearly all exposures exhibit strata horizontal in attitude. Exten-



sion of structural trends studied northward across the state line into Wisconsin indicate cross structures present in the northern part of the South Wayne, Monroe, and Brodhead quadrangles.

GEOLOGICAL APPLICATIONS OF THE IONIC POTENTIAL

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Introduction

Quite frequently we are reminded that the 96 known chemical elements are too complex to be classified by reference to any single characteristic. The periodic classification gives us only qualitative ideas, and many attempts have been made to place the elements on a more quantitative scale.

The role of ionic radii in the properties of chemical compounds has been emphasized by many authors including Pauling, Goldschmidt, and Bragg. Another factor influencing the properties of chemical compounds is the oxidation number or charge which an ion carries. In order to obtain a more comprehensive view of an ion and its properties, we must take into consideration both of these factors.

Definition

Increasing ionic charge and ionic radius act in opposite directions. That is, the lattice energy of a crystal is directly proportional to the charges and inversely proportional to the radii of the ions contained therein. From these considerations, Cartledge (1, 2) defined the ionic potential ($\varnothing$) as the charge on an ion divided by its radius. Table 1 gives a list of some common ions, their charges, radii, ionic potentials, and the square roots of their ionic potentials.

Table 1. Ionic Potentials

Ion	Charge	Radius*	$\varnothing$	$\sqrt{\varnothing}$
Cs^{+}	1	1.65	0.61	0.78
Rb^{+}	1	1.49	0.67	0.82
K^{+}	1	1.33	0.75	0.87
Na^{+}	1	0.98	1.02	1.00
Ba^{++}	2	1.43	1.40	1.18
Pb^{++}	2	1.32	1.52	1.21
Sr^{++}	2	1.27	1.58	1.26
Li^{+}	1	0.78	1.67	1.30
Ca^{++}	2	1.06	1.89	1.38
Zn^{++}	2	0.83	2.40	1.55
Fe^{++}	2	0.83	2.40	1.55
Mg^{++}	2	0.78	2.56	1.60
Th^{+4}	4	1.10	3.63	1.91
Ce^{+4}	4	1.02	3.92	1.98
Fe^{+++}	3	0.67	4.48	2.12
Zr^{+4}	4	0.87	4.60	2.15
Pb^{+4}	4	0.84	4.76	2.18
Al^{+++}	3	0.57	5.26	2 30
Be^{++}	2	0.34	5.90	2.43
Ti^{+4}	4	0.68	5.90	2.43
Mo^{*6}	6	0.62	9.7	3.11
Si^{+4}	4	0 39	10.2	3.18
P^{+5}	5	0.34	14.7	3.82
B^{+++}	3	0 20	15 0	3.87
S^{+6}	6	0.29	20.0	4.46
C^{+4}	4	0.20	20.0	4.46
N^{+5}	5	0.11	45.5	6.70

*The radii have been taken from V. M. Goldschmidt, Br. *60,* 1263 (1927).

These values of the ionic potential may be related to many geological concepts, of which seven will be considered.

Applications

1. If the square root of the ionic potential ($\sqrt{\varnothing}$) of a cation is less than 2.2, the oxide formed will be basic; if $\sqrt{\varnothing}$ is between 2.2 and 3.1, the oxide will be amphoteric; and if $\sqrt{\varnothing}$ is greater than 3.1, the oxide will be acidic. These data are summarized in Table 2 along with some examples.

Table 2.—Acidic-Basic Character of Oxides

$\sqrt{\varnothing}$	Nature of oxide	Examples
<2.2	basic	Na_2O, K_2O, CaO, MgO
2.2-3.1	amphoteric	Al_2O_3, BeO
>3.1	acidic	SiO_2, CO_2

2. When the $\sqrt{\varnothing}$ of the cation of a chloride is greater than 2.2., the chloride is volatile at a little above room temperature and one atmosphere pressure. This means that the chlorides of silicon, germanium, titanium, plumbic lead, etc. could be lost in volcanic eruptions.

3. The hardness of binary crystals increases as the ionic potentials of their constitutents increase. This phenomenon is illustrated in Table 3.

4. If the $\sqrt{\varnothing}$ of the cation of a carbonate or nitrate is greater than 2, the compound will not be stable; if $\sqrt{\varnothing}$ is between 2 and 2.5, basic carbonates are formed which are soluble in carbonate solution. Thus, zirconium, aluminum, beryllium and others may be dissolved in carbonate solutions as basic carbonates.

5. Goldschmidt (3, 4) has divided the cations into three groups according to their ionic potentials. Group I consists of cations whose ionic potentials are less than 3; they remain in true ionic solution in the processes of weathering and transportation. An example of this is the presence of sodium, potassium, magnesium, calcium, and strontium in sea water. Group II is made up of cations which have ionic potentials between 3 and 6. These ions are precipitated by hydrolysis, examples being the presence of aluminum and beryllium in clays. Cations with ionic potentials greater than 6 comprise Group III. They form complex anions containing oxygen, some of them again being soluble. Examples of these are the silicates, phosphates, carbonates, borates, and nitrates.

6. Elements whose ionic potentials are less than 2 are found to be easily collected and exchanged by natural zeolites.

7. Elements with high ionic potentials enrich in silicates. Goldschmidt (4, 6) says that the limit is about 2.6 at ordinary temperature, but that the limit changes with the temperature.

Table 3.—Hardness of Binary Crystals

Compound	NaF	MgO	ScN	TiC
Hardness (Moh's)	3.2	6.5	7-8	8-9
$\sqrt{\varnothing}$ cation	1.00	1.60	1.90	2.43
$\sqrt{\varnothing}$ anion*	0.86	1.19	1.32	1.38

*Values for the anions are calculated by neglecting the negative sign to facilitate the taking of the square root.

Conclusions

The concept of the ionic potential is very useful to the instructor as a teaching aid, and also to the research worker as a simple means of remembering various relations. The user is warned, though, because the idea is not infallible; but it is nevertheless applicable to many problems. Other references are provided for further reading.

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UNUSUAL OOLITE GRAINS FROM THE STE. GENEVIEVE LIMESTONE*

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In connection with other studies of Illinois limestone resources it was noted that a massive bed of oolite, 6 to 8 feet thick, in the upper part of the Ste. Genevieve formation in the quarry at Anna, Illinois, contained oolite grains and other grains of unusual character as compared to the common Ste. Genevieve type oolite grains, which are characterized by rounded centers, mostly of undeterminable origin surrounded by one or more annular calcite deposits. Pictures of a number of these unusual grains are included. No attempt is made to interpret the origin of the grains themselves, or their broader significance in relation to the mode of formation or subsequent history of the Ste. Genevieve formation, because the data now available are inadequate, but some interesting possibilities are self-evident from the pictures (figs. 1-6).

The specimens studied were prepared by sawing and grinding a plane surface on each, and etching the surface with dilute hydrochloric acid. This produced a semi-polished finish which revealed well the textural details of the specimens. Insoluble impurities projected above the surfaces of the specimens. The figures shown are made from photomicrographs taken by reflected light at magnifications of 12 to 30X, except as otherwise noted.

The unusual grains observed may be classified into five groups: (1) oolite grains with recognizable fossils as centers; (2) compound oolite grains; (3) grains composed of oolite rock; (4) oolite grains with clear crystalline calcite centers; and (5) partial or disrupted grains. The number of photomicrographs shown for each type of grains is not necessarily proportional to the numbers occurring in the samples studied.

Heinz Lowenstam of the Survey staff identified the fossils.

Description of Figures

Figure 1 is a photomicrograph of typical Ste. Genevieve oolite taken at a magnification of 10X. Some grains have large dark calcite centers surrounded by a single ring of calcite. Others have smaller centers with one or more annular deposits around the center. The dark areas between the grains are also clear crystalline calcite in this figure and other figures which follow.

Figure 2 shows grains of the type that have fossils as centers. In the upper left is an oolite grain composed of a foraminifera, possibly endothyra, surrounded by a single ring of calcite. In the lower left is a grain whose center is an arm plate of a crinoid having two annular deposits around it. Grains with crinoid arm plate centers are generally abundant in the Ste. Genevieve oolite. The grain in the upper right shows a longitudinal cross-section of a minute gastropod surrounded by a

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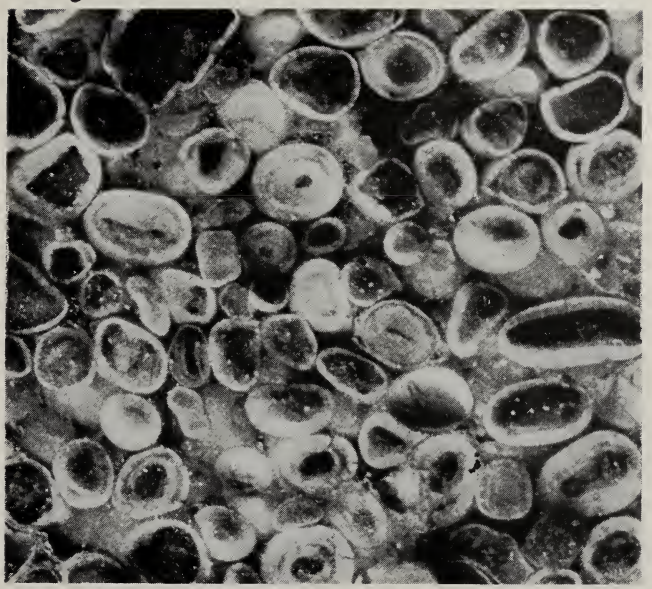

FIG. 1.—Typical Ste. Genevieve oolite.

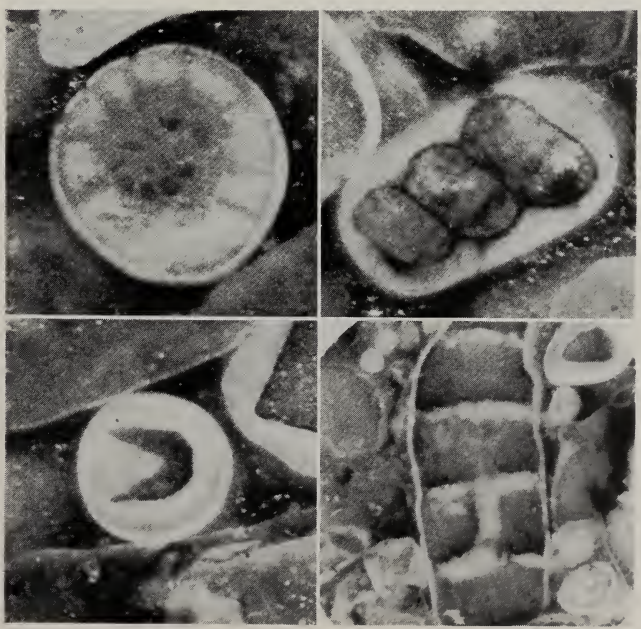

FIG. 2.—Oolites with recognizable fossil centers.

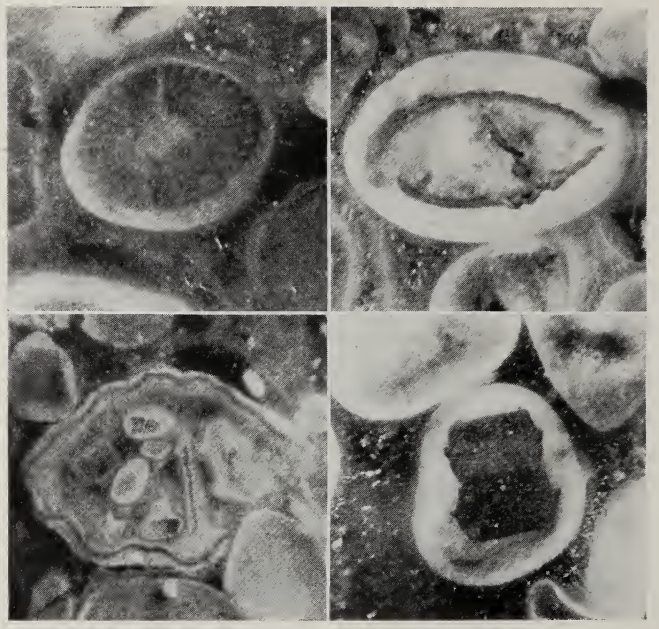

Fig. 3.—Oolites with recognizable fossil centers.

single thick calcite ring. The grain at the lower right is a fossil, not positively identified, but possibly a longitudinal section of a crinoid stem showing a residual central canal. Note the thinness of the calcite ring around this fossil. This last photomicrograph has a magnification of 12X as compared to 30X for the other grains shown.

Figure No. 3 shows more grains with fossil centers. In the upper left is a cross-sectioned coral with a single calcite ring. A transverse cross section of a brachiopod with a single thin white calcite ring is shown in the lower left. The interior of the brachiopod contains other smaller oolite grains. In the upper right is another brachiopod in longitudinal cross section surrounded by a thick deposit of calcite, as is likewise a piece of crinoid stem in the lower right, which is displayed in longitudinal cross section. All grains shown have a magnification of 30X.

Figure No. 4 shows in the upper left a compound oolite grain having two well defined centers surrounded by annular calcite deposits. A third center appears on the right side of the grain. The outermost thin calcite ring surrounds this third center as well as the rest of the composite grain. The other grains shown in the figure are oolite rock. They have no annular deposits around them and appear to have been derived from a consolidated oolite which was being eroded at the time the bed from which these specimens came was deposited. The oolite grains within the fragments of oolite rock are of the type previously described as usual for the Ste. Genevieve formation. The photomicrographs in

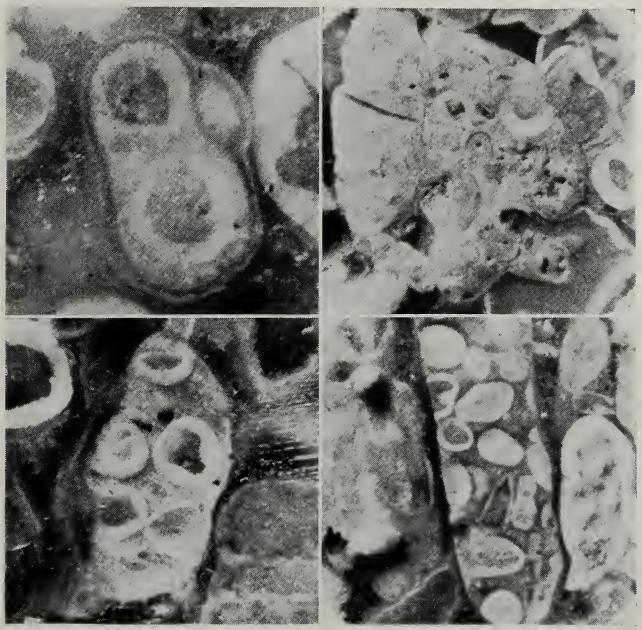

FIG. 4.—Compound colite grain and grains of oolite rock.

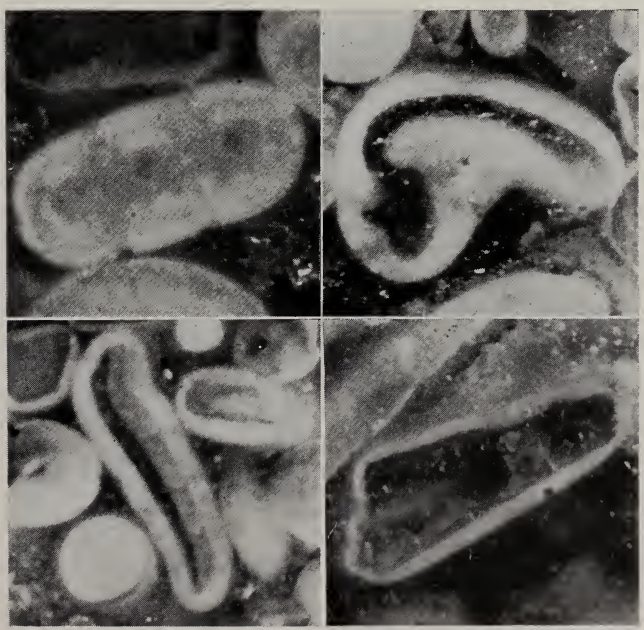

FIG. 5.—Compound oolite grain and grains with clear crystalline calcite centers.

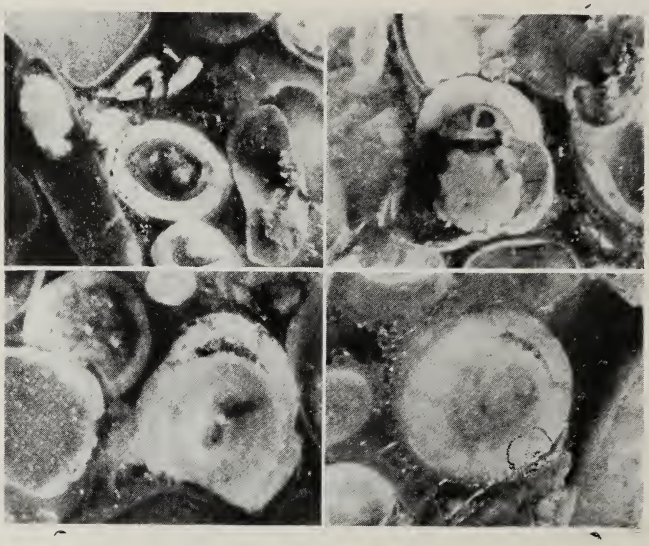

Fig. 6.—Partial grains and disrupted grains.

this figure have a magnification of 12X, excepting the upper left which has 30X.

Figure No. 5 shows in the upper left another compound grain with 3 centers, all enclosed by a calcite ring. The remainder of the figure illustrates oolite grains with clear calcite centers, which in the photomicrographs are dark gray or nearly black. The grain in the lower left is one whose center is only half crystalline calcite. The grain in the upper right appears to have had a brachiopod, shown in longitudinal cross section, as its center. The white calcite envelope on the concave side of the shell is of unusual thickness. The grain in the lower right is of interest because of its angular outline. The photomicrographs in this figure have a magnification of 12X.

Figure No. 6 shows the disrupted and partial grain type. In the lower left disruption of the exterior portion of the grain is evident, probably as a result of the growth of crystalline calcite, indicated by the dark area. The same phenomenon is shown in the grain at the lower right and in the upper left. Also in the upper left there appears the white calcite envelope of an oolite grain which has been broken and deformed and whose center is no longer evident. Partial grains, which appear to be the result of the solution of one grain at its contact with another, are well shown on the left side of the lower left picture. In the upper right picture, a series of two partial grains are shown. In the whole grain projecting silica casts a shadow on the surface. The photomicrographs in this figure have a magnification of 25X with the exception of the upper right which has 10X.

PHYSICS

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* 1. A Circuit for Comparing the Sensitivities of Galvonometers: Frederick H. Giles, Wheaton College, Wheaton.

* 2. Oil Flotation of Illinois Coal Fines: Robert J. Piersol, Illinois State Geological Survey, Urbana.

* 3. Neutron Induced Radioactivity in Iron and Chromium: R. F. Paton and R. B. Duffield, University of Illinois, Urbana.

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* 5. A New Design for a Radio Antenna: Clayton Howard, Wheaton College, Wheaton.

* 6. Great Probability of the Existence of Atoms with Negatively Charged Nuclei—Especially in Stars of High Density: O. B. Young, Southern Illinois Normal University, Carbondale.

7. The Endurance Limit of a Free-cutting Brass Rod: H. L. Walker and M. Baskal, University of Illinois, Urbana.

* 8. Coefficient of Sound Absorption—A Stationary Wave Method in which no Exploring Device is Used: H. O. Taylor, Wheaton College, Wheaton.

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ENDURANCE LIMIT OF A FREE-CUTTING BRASS ROD

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Free-cutting brass rod is the most important of all the leaded brasses. Each year millions of pounds are consumed in the manufacture of screws, nuts, bolts, door hinges, and general hardware of all kinds. This product has excellent plasticity within the temperature range of 1200° to 1450° F. and can be extruded into intricate shapes; however, it cannot be hot-rolled or forged because of its high lead content. It is usually fabricated by hot extruding and/or cold drawing to size and shape. For best machining properties the product is furnished in the cold drawn condition.

Lead is virtually insoluble in alloys of copper and zinc, and when present it occurs as finely divided and more or less evenly distributed globules of lead. The presence of lead in brass does not appreciably influence the mechanical strength or corrosion resistance of the parent alloy but it does drastically reduce the bending, cold-heading, and upsetting operations, which can be performed with comparative ease in most of the unleaded copper-zinc alloys. The one reason why lead is added to brass is to improve its machinability. The presence of lead uniformly distributed in a brass alloy causes chips to break off and, since the chips are practically undistorted and are only momentarily in contact with the tool face, very little heat is transmitted to the cutting tool.

Purpose of Investigation

Free-cutting brass rod is essentially common brass rod (63% Cu, 37% Zn) to which approximately 3% Pb has been added. The presence of lead does not appreciably influence the mechanical strength of the common brass rod as is shown by the following data: Common brass rod, 62.7% Cu; Pb 0.03%; Zn balance, grain size 0.045 mm. diameter ready-to-finish, cold drawn 30%, has a tensile strength of 70,000 psi. Free-cutting brass rod, 61.7% Cu; 3.35% Pb; 34.9% Zn, grain size 0.040 mm. diameter ready-to-finish, cold drawn approximately 30%, has a tensile strength of 67,000 psi.

Because of the presence of lead particles in the microstructure of free-cutting brass rod there is an excellent opportunity for the lead to act as stress-raisers and materially affect the endurance limit. There are only a limited number of references in the literature to the endurance limit of leaded brasses, therefore it was believed that such an investigation would be of value.

Apparatus

All tests were made on a Farmer machine of rotating simple beam type, in which the outermost fibers of a solid cylindrical specimen are subjected to cycles of completely reversed stress from tension to compression, under constant load.

*An abstract of a thesis presented by M. Baskal in partial fulfillment of the requirements for the degree of Master of Science in Metallurgical Engineering, University of Illinois.

FIG. 1.—Brass rod, cold drawn approximately 30%. Structure shows grains of alpha and beta solid solution. The dark stringers are particles of undissolved lead. Average grain size 0.040 mm diameter. Etched with 1 part H_2O_2 plus 4 parts 50% NH_4OH. Magnification 100 diameters.

FIG. 2.—Brass rod annealed at 1050° F. for 2½ hours. Elongated grains of cold-drawn condition have been replaced by strain free equiaxed grains. Structure is essentially alpha solid solution grains with coalesced globules of lead. Grain size 0.040 mm diameter. Magnification 100 diameters. Etched in hydrogen peroxide plus ammonium hydroxide.

The specimens were of standard size: 4.0 inches long, 0.300 + 0.003 inch minimum diameter, and 5.0 inch radius. The ends of the specimens were threaded internally to facilitate a tight grip in the chucks. The surface was polished parallel to the axis with No. 00 metallographic paper.

Material and Procedure

The free-cutting brass rod was of ⅝ inch diameter, cold-drawn approximately 30%, with a ready-to-finish grain size of 0.040 mm. diameter.

The chemical analysis was:

Copper	61.70%
Lead	3.35%
Zinc	34.90%
Total	99.95%

The structure of the bar in the as-received condition consisted of alpha and beta brass, plus particles of lead; and the structure is illustrated in figure 1.

A series of as-received brass specimens was given a heat treatment to eliminate beta brass and produce a grain size equal to the ready-to-finish grain size. The treatment consisted of heating to 1050° F., holding for 2½ hours at that temperature in an electrical resistance furnace, followed by quenching in water. The grain size produced averaged 0.040 mm. diameter. The structure showed complete recrystallization but no appreciable beta phase, and is illustrated in figure 2. Another series of brass specimens was heat treated to produce a grain size twice as large

as the ready-to-finish grain size and to eliminate the presence of beta phase. The heat treatment consisted of heating to 1500° F., holding for 3½ hours at that temperature, cooling to 1050° F. and holding at 1050° F. for 7½ hours, followed by quenching in water. The grain size produced averaged 0.080 mm. diameter. The structure showed complete recrystallization and coalescence of the grains but no beta phase, and is illustrated in figure 3.

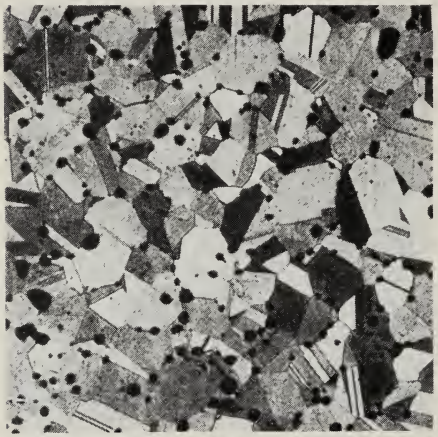

Fig. 3.—Brass rod annealed at 1500° F. for 3½ hours. Structure consists of alpha solid solution and globules of lead. Grain size 0.080 mm diameter. Magnification 100 diameters. Etched in hydrogen peroxide and ammonium hydroxide.

The specimens were rough machined, heat treated, finish machined, and polished. An initial load of approximately 0.6 times the tensile strength was used. The load was continuously reduced until failure did not take place in 50 million cycles of reversed stressing. The specimens annealed at the higher temperature, to produce a large grain size, could not be loaded with a load greater than 25,000 psi without causing plastic deformation when the load was applied.

Table 1.—Fatigue and Mechanical Properties of Free-Cutting Brass Rod

Material	Rockwell B hardness	Ultimate strength psi	% Elongation in 1.2 inch gage length	% Reduction of area	Endurance limit psi	Cycles of stress
Brass, cold drawn approx. 30%. Av. grain dia. 0.040 mm.	73	67,000	22.4	51.1	16,500	$50x10^6$
Brass annealed 2½ hrs. at 1050° F. Av. grain dia. 0.040 mm.....	17	52,000	64.1	51.6	18,000	$50x10^6$
Brass annealed 3½ hrs. at 1500° F., cooled to 1050° F., held 7½ hrs. Av. grain dia. 0.080 mm.	13	45,300	65.2	58.5	17,500	$50x10^6$

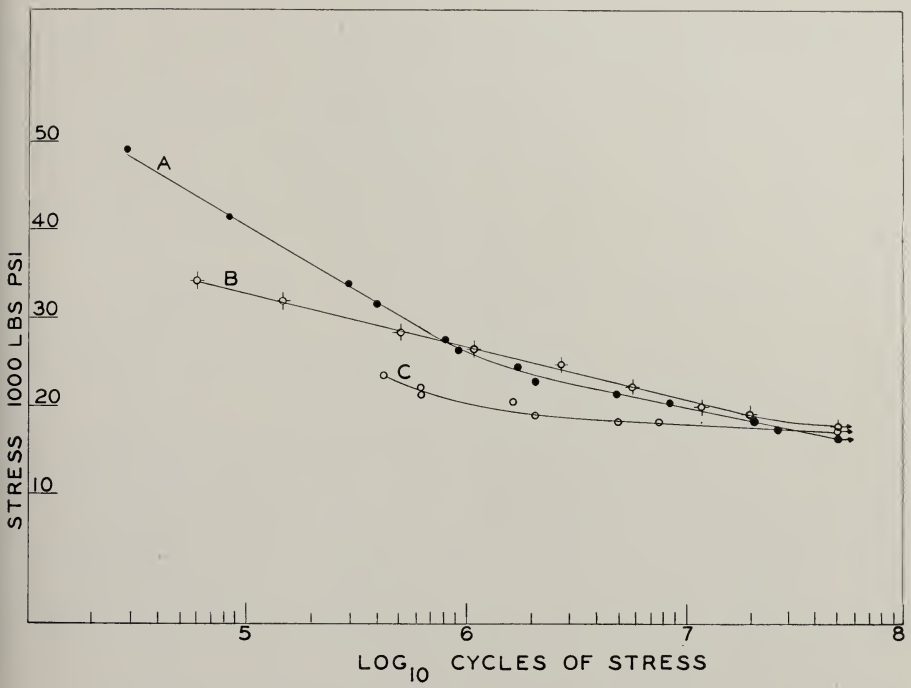

Fig. 4.—Stress versus cycles of stressing to produce failure in a free-cutting brass rod.

Curve A. Cold-drawn approximately 30% reduction in area.

Curve B. Annealed at 1050° F.

Curve C. Annealed at 1500° F.

Arrows indicate no failure for conditions of stress and cycles of stressing.

Discussion of Results

The mechanical properties of the free-cutting brass rod in the three conditions of testing are shown in table 1. The loss in hardness and strength, and increase in elongation with the first heat treatment, shows recrystallization was complete and coalescence of grains had taken place. When the grain size was doubled by coalescence, in the second heat treatment, a further loss in strength and hardness was found, but the ductility was less affected.

The stress in pounds per square inch and the number of cycles of reversed stressing, to produce failure, are tabulated in table 1; and the data are plotted in figure 4 in the conventional manner of stress vs. cycles of stressing on a semi-logarithmic plot.

The rod in the as-received condition with approximately 30% cold deformation showed a continuously lowered stress for cycles of stressing up to 50,000,000 cycles. The slope of the curve for failure decreases at stresses of less than 25,000 psi. However, with cycles of stressing up to 50,000,000 cycles the S-N curve had not become horizontal, and a stress

had not yet been reached in which it could be said a safe load had been reached for an infinitely large number of repeated cycles of stressing.

The specimens which had been annealed for 2½ hours at 1050° F., and with the same grain size as the ready-to-finish grain size before cold drawing, show an initially lower stress for a small number of cycles. The relation of stress vs. cycles of stressing is linear from 200,000 to 10,000,000 cycles of stress. Curiously, the load-carrying ability of these specimens, for cycles of stressing greater than 1,000,000 and up to 50,000,000, is somewhat better than for the cold drawn specimens.

The specimens which had been annealed for 3½ hours at 1500° F., followed by holding at 1050° F. for 7½ hours, would not take an initial load in excess of 25,000 psi without plastically deforming under the load. The load-carrying ability of these specimens of large grain size was materially lower than for the cold drawn specimens, or for the specimens annealed at the lower temperature and with a grain size only half as large. The relation of stress vs. cycles of stressing is linear and parallel to the specimens of smaller grain size with cycles of stressing up to 5,000,000 cycles. At 5,000,000 cycles the slope of the curve decreases and the curve is practically horizontal from 5,000,000 to 50,000,000 cycles.

The three curves, for the three specimens in different conditions, practically meet at a constant value of stress for 50,000,000 cycles of stressing. Thus, it is indicated that for an infinitely large number of cycles the annealed rod has the ability to carry as large a load as the cold drawn rod.

Conclusions

Based upon the results obtained in this experiment the following conclusions may be summarized:

1. Cold drawing of leaded-brass does not increase the load-carrying ability of the metal for 50,000,000 cycles of reversed stress.

2. Based upon 50,000,000 cycles of reversed stressing there is no indicated safe load for an infinite number of reversals of stressing, such as is exhibited by ferrous alloys.

3. Cold drawing a leaded-brass does increase the load-carrying ability, under complete reversal of stressing, for cycles of stressing less than 1,000,000 cycles.

4. The endurance limit of leaded-brass is not affected by increasing the grain size from 0.040 to 0.080 mm. diameter, for a large number of stress cycles.

5. It may be safely concluded that the globules of insoluble lead found in leaded-brass tend to act as localized stress raisers and thus prevent the homogeneous distribution of stress across the matrix of the alloy.

PSYCHOLOGY AND EDUCATION

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* 2. Basic Misunderstandings between Professors of Liberal Arts and of Education: Edwin H. Reeder, University of Illinois, Urbana.

* 3. National Study of Teacher-education Scholarships: Eugene R. Fair, Southern Illinois Normal University, Carbondale.

* 4. Causes of Severe Reading Retardation: Helen Robinson, University of Chicago, Chicago.

* 5. Testing our Tests of Physical Fitness: D. M. Hall, University of Illinois, Urbana. (movie and slides)

* 6. Research in Progress in the Student Personnel Bureau at the University of Illinois: William M. Gilbert, University of Illinois, Urbana.

* 7. The Counseling Services of the Student Personnel Bureau of the University of Illinois: Leo Helmer, University of Illinois, Urbana.

* 8. Facts About the Teacher Situation in Illinois: J. W. Carrington, Illinois State Normal University, Normal.

* 9. A View of the Illinois High School Student through a Statewide Testing Program: J. Thomas Hastings, University of Illinois, Urbana.

*10. Relationships between the High School and College Editions of Certain Psychological Examinations: Don F. Thomann, University of Illinois, Urbana.

*11. Predicting Teacher Success: Emily G. Dunn, Lindsey Morris, and James Goff, Illinois State Normal University, Normal.

12. Sex Deviatons in the Selection of Masculine and Feminine Words in Poetry: David Manning White, Bradley University, Peoria.

* Not published.

SEX DEVIATIONS IN THE SELECTION OF MASCULINE AND FEMININE WORDS IN POETRY

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The question as to whether words in the English language possess valences toward "masculinity" or "femininity" is, of course, a very complex one. At one time or another, however, almost everyone has heard someone say, or perhaps has thought to himself, this word has a distinctly *feminine* sound, or that word is certainly *masculine*.

The purpose of this brief study is to examine the differences in the selection of "masculine" and "feminine" words by 100 male students and 100 female students at Bradley University. Although this is merely a preliminary study, the results seem to indicate that an examination of the subject's attitude toward words from poetry can serve as a projective technique in order to ascertain *maleness* or *femaleness* in the subject.

The students who participated in this test were given a mimeographed sheet of paper with the three poems. The authors of the poems were, obviously, not given. The students were asked to designate whether they thought the poem was written by a man or woman. They were asked, secondly to list any words, which, in their opinion were masculine or feminine sounding. They were asked to list the masculine or feminine words which had been instrumental in determining for them that the writer of the poem was a man or woman.

The same students who took the poetry test were later given a second test. This is a preliminary test by Arthur Weider, Assistant Professor of Psychology at Bradley University, which sets up a masculinity-femininity scale. This is done by filling out a work-interest blank, which is a disguised occupational preference blank, wherein the subject encircles L (Like) or D (Dislike) for a list of twenty occupations. The subjects are asked to indicate in this list those which he likes or dislikes. A previous study of homosexuals incarcerated at Rikers Island, a penal institution in New York harbor, for asocial behavior, as well as effeminate and homosexual subjects, demonstrated in a statistically reliable manner that certain occupations, e.g., interior decorator, dancer, window dresser, etc, were chosen by these homosexuals with great frequency. This fact is utilized in the Weider scale for the purpose of deriving conclusions concerning the individual's ability to accept the male patterns of our society.

Examining the selection of words from the poetry in a general way, it is interesting to note that in the list of feminine words chosen by male subjects the words *lovely* and *desired* have high frequencies, while neither word was in the corresponding female list. The strong feminine connotation of the word *sea* for male

subjects was not shared by the women. In only one word did both sexes concur; both chose *lilies* as the most feminine word.

Perhaps more significant are the female choices in this respect. The female choices of the feminine words suggest the spring season of the year. The period of growth and verdancy is perhaps strongest in the female mind as the symbol of fertility and motherhood. On the other hand, the female choice of masculine words reveals an almost diametric concept, one that suggests winter and hiemal dormancy.

In both groups the word *storms* had a very high masculine frequency, as did the words *hail* and *wind*.

How can such word choices serve as a projective technique in determining maleness or femaleness in the subject? To validate the frequency lists the individual tests, i.e. selecting the words from the poetry, were compared with the same subject's score on the Weider masculinity-femininity scale For example, subject A, female, 19 years old, had an M-F score of F-5, which indicates an adequate acceptance of female patterns. The words that she listed as feminine included *lilies, silently* and *spring;* her masculine choices included *storms* and *death*. In only one word did she go over to the male lists. That was her choice of *sea* as a feminine word.

Another female subject, age 20, had a very high F score on the F-M scale, an F 22, indicating a very strong acceptance of the female patterns and/or rejection of the male patterns. The four words she selected, *lilies, green swell* (in her feminine selections) and *storms* and *scalding* (in her masculine selections) are exclusively in the female frequency lists.

Another female subject, age 22, had a score of M-8 on the M-F scale, indicating a deviation from the acceptance of female patterns. Accordingly, one could expect a selection on her part of several words from the male frequency lists. Of the five words she listed, two of them came from the male lists, *sea* and *desired,* and the other three words were those which were common to both groups, i.e., *lilies, storms* and *wind*. She chose no words from the female frequency lists.

Collating the individual male tests with the same subject's M-F scale produced similar results to the cases which I have just listed. It should be understood, however, that there were several cases, both male and female, in which the words selected did not follow the general trend. Although they showed a good acceptance of maleness or femaleness on the M-F tests, the subjects selected words from the opposite sex's frequency list. However, it may be significant to point out that a very large percentage of the subjects had a close correlation between their M-F scales and the words which they selected as masculine and feminine. Of the women tested 78 percent chose words from the frequency lists in proportion to their M-F scales, and 69 percent of the men did the same.

As I have suggested, this study is merely the preliminary step in a very complex problem. If, however, further testing, perhaps with different and better poems, continues to indicate that there is a strong cor-

relation between the M-F scale and the words selected, a test can be devised which will serve as a projective technique to further ascertain acceptance or deviation from the male or female patterns of our society.

POEMS USED IN STUDY

1

I have desired to go
Where spring not fail,
To fields where flies no sharp and sided hail.
And a few lilies blow.

And I have asked to be
Where no storms come,
Where the green swell is in the haven dumb,
And out of the swing of the sea.

—Gerard Manley Hopkins

2

White sky, over the hemlocks bowed with snow
Saw you not at the beginning of evening the antlered buck and his doe
Standing in the orchard? I saw them. I saw them suddenly go,
Tails up, with long leaps lovely and slow,
Over the stone-wall into the wood of hemlocks bowed with snow.

Now lies he here, his wild blood scalding the snow.

How strange a thing is death, bringing to his knees, bringing to his antlers,
The buck in the snow.
How strange a thing,..a mile away by now, it may be,
Under the heavy hemlocks that as the moments pass
Shift their loads a little, letting fall a feather of snow—
Life, looking out attentive from the eyes of the doe.

—Edna St. Vincent Millay

3

Now close the windows and hush all the fields;
If the trees must, let them silently toss;
No bird is singing now, and if there is,
Be it my loss.

It will be long ere the marshes resume.
It will be long ere the earliest bird.
So close all the windows and not hear the wind,
And see all wind-stirred.

—Robert Frost

Lists of the five most frequently selected words in each category chosen by male and female students.

Male Students		*Female Students*	
Masculine Words	Feminine Words	Masculine Words	Feminine Words
1. wind (41)	1. lilies (54)	1. storms (57)	1. lilies (48)
2. storms (38)	2. lovely (51)	2. hail (46)	2. spring (41)
3. hail (33)	3. desired (42)	3. scalding (39)	3. green swell (36)
4. snow (30)	4. sea (37)	4. death (33)	4. silently (29)
5. blood (27)	5. feather (31)	5. wind (28)	5. feather (17)

SOCIAL SCIENCE

S. R. KAMM, *Chairman*
Wheaton College, Wheaton

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* 1. The Autonomy of Scholarship: Daniel J. Boorstin, University of Chicago, Chicago.

2. Problems of Constitutional Reform in Illinois: Lynford A. Lardner, Northwestern University, Evanston.

* 3. Culture Pattern of an Ethnic Island in Rural Wisconsin: Oscar F. Hoffman, Elmhurst College, Elmhurst.

* 4. Cultural Areas in Peoria: Clarence W. Schroeder, Bradley University, Peoria.

5. Problems of Old Age in a City of 100,000: Ruth Shonle Cavan, Rockford College, Rockford.

* 6. Residential Development in Suburban Milwaukee County: Richard Dewey, University of Illinois, Urbana.

*Not published.

OLD AGE IN A CITY OF 100,000

RUTH SHONLE CAVAN
Rockford College, Rockford

Rockford is an industrial city in northern Illinois, which had a population in 1940 of approximately 85,000 within the city limits and 20,000 in the suburbs immediately adjacent to the city. Of the urban population, 6,458 were aged 65 and over and of the suburban population, 988. As is true of many cities, this community is just beginning to realize that old age presents many serious problems in addition to the economic one.

An understanding of old age problems, both psychological and social, must rest upon a factual survey of the type of old people in the community and of their living arrangements and activities.[1] The Census for 1940 gives an over-all picture of the type of old people who live in the community and where they live. Additional material comes from interviews with 205 persons aged sixty and over and from community agencies, industries, and churches.

In general, old age is a problem which has crept into the community unnoticed and which will not reach its full significance for some years to come. In Rockford, the percentage of the population that is 65 years of age and over has increased from 5.1 in 1900 to 7.6 in 1940. For the suburbs in 1940 the percentage was slightly lower, 7.0. In accordance with estimated future increases for the total United States, old people in Rockford will probably reach 11 or 12 percent of the population by 1980.[2] Old people in Rockford as in other cities represent an increasing group whose needs must receive attention if the community is to avoid having a fairly large segment of its adult population without integration in the community life.

Whenever part of the population can be set off with some definite characteristic there is a tendency to think of the members of the group as all being very much alike and to apply stereotyped attitudes to them. Old people are not all alike. In fact they are as different in personality and in social experiences as any other group of adults classified by age.

In Rockford, which has several foreign-born communities, 45 percent of all persons 65 years of age and over are foreign-born; 0.7 percent are Negroes. The foreign-born represent a far greater proportion of the old people than they do of the total population, for only 16 percent of the total population are foreign-born. The Negroes represent a smaller percentage, as 1.4 percent of the total population is Negro. The foreign-born in Rockford are essentially Swedish and Italian. The peak of immigration was sometime in the past so that the foreign-born repre-

[1] Much of the material used in this paper was assembled incidental to a study of social adjustment in old age made by the writer as Research Associate for the Subcommittee on Social Adjustment in Old Age of the Social Science Research Council; additional material was secured by four senior students at Rockford College: Barbara Conklin, Joyce Gayle, Susan Eckels, and Elizabeth Siegfried.

[2] Bureau of the Census, Population—Special Reports: Series P-46, No. 7. September 15, 1946.

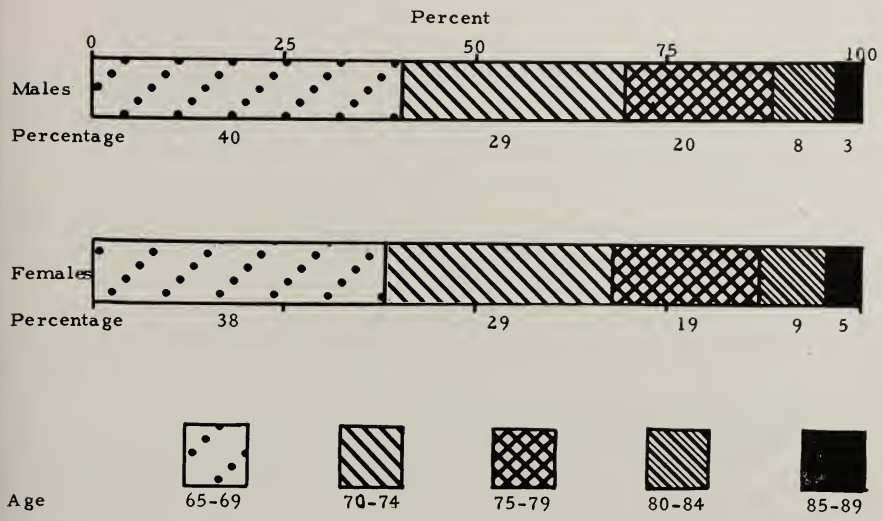

Fig. 1.—Percentage distribution of males and females aged 65 and over, by five year periods, for Rockford, Illinois, 1940. Based on Sixteenth Census of the United States, 1940, *Population*, Vol. IV. Part II, p. 614.

sent an aging group. The Negroes came in primarily at the time of the first world war as young workers who have not reached old age. Any program which penalized foreign-born people would work a great hardship on almost half the old people in the community. Also any program that overlooked the characteristic cultural, religious, and language patterns of the dominant foreign-born groups would fail of its purpose.

Although we tend to group everyone who is 65 and over into one category called old age, it is important to realize that actually this group has an age span that runs from 65 to 100 or 35 years. Two-fifths of the old people are between the ages of 65 and 69, that is, they are little different from the group that we think of as middle-aged. Many of them are still employed. We do not have the employment status by age groups for Rockford, but for the United States in 1940, 52.0 percent of the men and 8.6 percent of the women between ages 65 and 69 were employed. Twenty-nine percent of the old age group is aged 70-74 and of this group for the United States 35.4 percent of the men and 4.7 percent of the women are employed. One-fifth of the old age group is between 75 and 79 years of age, and the proportion employed has decreased greatly. Less than ten percent of the old age group is between 80 and 84 years of age and less than 5 percent over 85 (fig. 1). About one-third of all old people must therefore be thought of as able-bodied, employed, and independent. More than half are still reasonably active. The proportion that may be termed aged and that is in need of protective personal care as well as economic assistance is relatively small. Plans for housing, physical

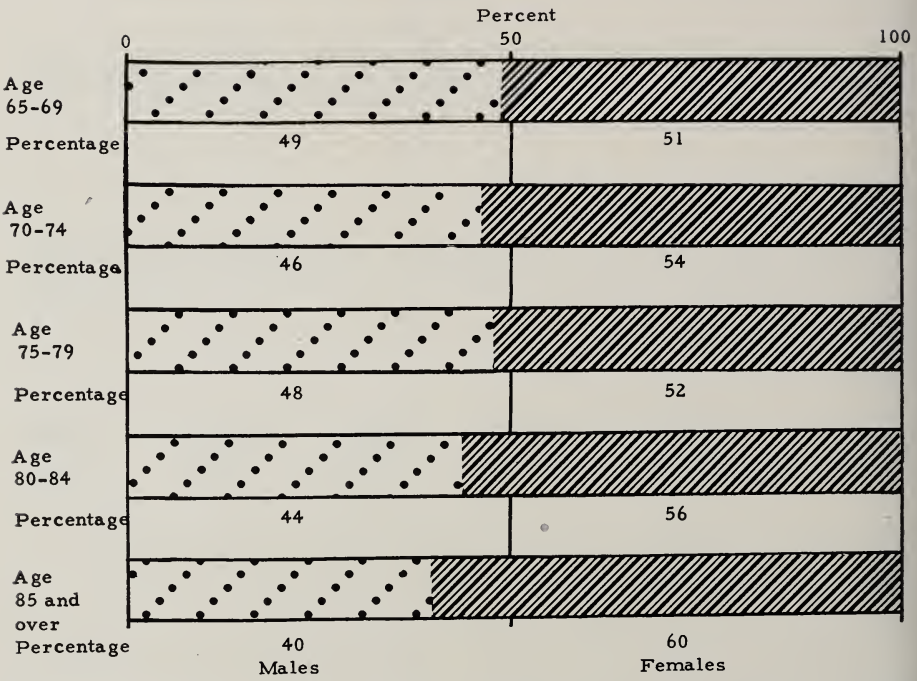

FIG. 2.—Percentage of males and females by age periods for Rockford, Illinois, 1940. Based on Sixteenth Census of the United States, 1940, *Population*, Vol. IV, Part II, p. 626.

care, recreation, and occupation should include a gradation that runs from facilities suitable to completely able and independent people to facilities for those who are physically and mentally helpless. Any one program would serve only a portion of the old age group.

The old age group is unevenly divided between the sexes with women in the majority. For the total old age group there are 12 percent more women than men. Because the death rate is higher for men than for women, with each succeeding year the ratio of women to men becomes greater. At age 65-69 women are only slightly in excess of men. In Rockford at this age women constitute 51 percent of the group. By the time age 85 and over is reached, women constitute 60 per cent of the group (fig. 2). Aged women therefore represent a special group.

Although the death rate is higher for old men than for old women, it is high for both groups and these two facts combined create a very large number of widows and widowers, but especially of widows. As early as age 65-69, 41.7 percent of all women are widows as compared with 16.6 percent of men who are widowers. The proportion of both widows and widowers increases rapidly until, for age 85 and over, 84.9 percent of all women and 65.3 percent of all men are widowed (fig. 3). It is probable that some of those included with the married have been widowed

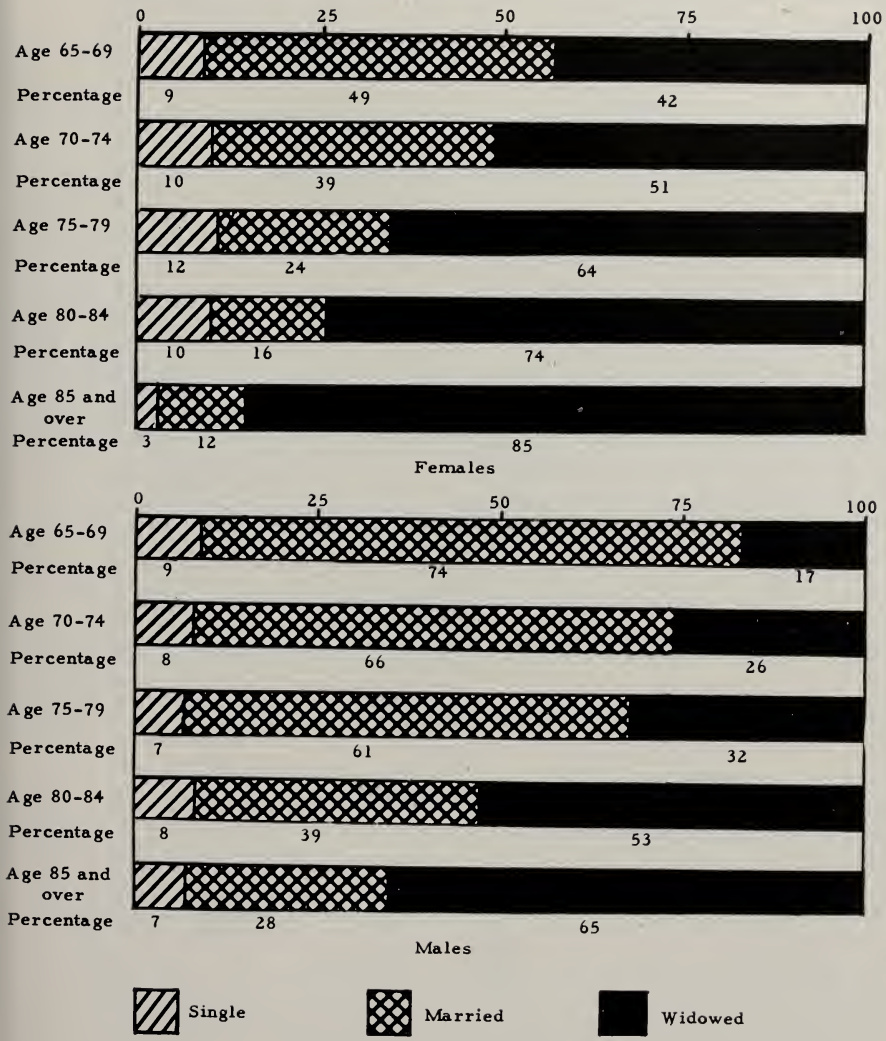

FIG. 3.—Percentage distribution by marital status for males and females according to age periods for Rockford, Illinois, 1940. Because of the small number, divorces and separations are omitted. Based on Sixteenth Census of the United States, *Population*, Vol. IV, Part II, p. 620.

during old age but have remarried. This statement applies especially to the men, who find remarriage simpler than do old women, and who often marry persons not included in the old age group. When these figures are interpreted in human qualities, we are forced to think of old age as a period of increasing family disintegration through death of the husband or wife and therefore of loneliness, detachment from intimate family groups, and often the breakup of the family home and the

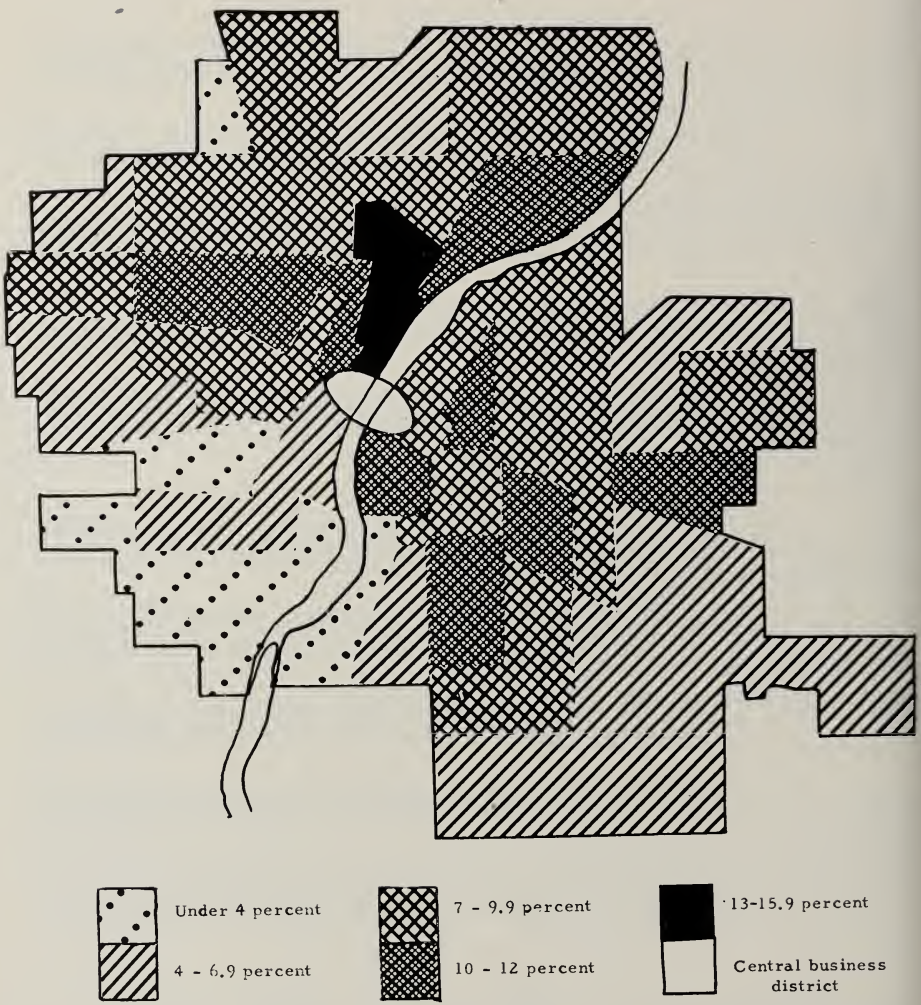

Fig. 4.—Percentage of the women in each enumeration district that was 65 years of age or older, Rockford, Illinois, 1940. Data from the Bureau of Census.

necessity of adjustment to new living arrangements.

Age 65 is coming to be accepted as the time for people to retire from active employment. Retirement usually means lowered income and often a state of complete dependency either upon public agencies or upon adult children. The sources of support for old people in Rockford can only be estimated. About 13 percent of the group receives state Old-age Pensions, averaging $41 per month; about 25 percent receives payments under Social Security benefits, averaging about $26 per month. Small groups of policemen, firemen, postal employees, and teachers receive pensions. Few of the industries have pension plans, although some are in-

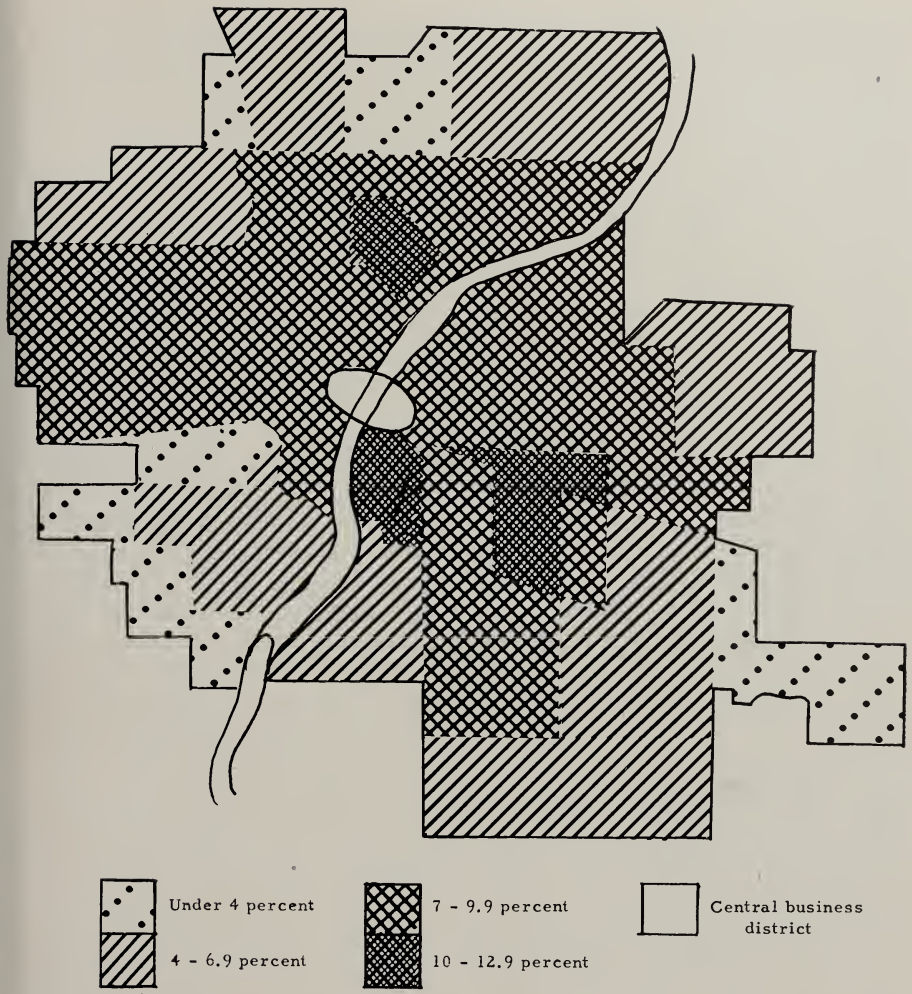

FIG. 5.—Percentage of men in each enumeration district that was 65 years of age or older, Rockford, Illinois, 1940. Data from the Bureau of Census.

augurating them. It seems to be a reasonable estimate that more than half of the old people are supported by their own earnings, savings, or their adult children. For many old people the entrance upon old age means the loss of economic security, lowered socio-economic status, movement to cramped living quarters, and drastic curtailment of social activities. Adjustment to these changes may be as serious as adjustment to the death of husband or wife. When for an elderly woman, the death of the husband coincides with loss of income, she may face adjustment to both loneliness and lower socio-economic status at the same time.

Although health figures are not available for Rockford, we know

from general information and the National Health Survey that old people suffer from more illness than do younger people and also are subject to many chronic diseases and physical defects. On the average, persons 65 years of age and over suffer about five weeks of disabling illness per year.[3] Chronic diseases and physical handicaps include arthritis, high blood pressure, heart disease, arteriosclerosis, failing sight and hearing, and general physical enfeeblement. All these handicaps in some way limit activity and participation in social activities; many of them cause recurrent or chronic pain; and some of them make the person bedfast or otherwise totally dependent upon others for physical care. Any plan for the care of the old or for occupations and recreation must be adjusted to different types and different degrees of physical disability.

Although there are no communities composed solely of old people in the city of Rockford, neither are old p e o p l e distributed evenly throughout the population. Maps were made to show the percentage of old people in each enumeration district used for the Census of 1940 (figs. 4 and 5). The communities with the lowest percentages of old people are on the outskirts of the city and in the suburbs. One area with a population of 167 people has only one old person. An area with 1217 has only 49 old people. In many only 3 or 4 percent are 65 or older. These are the communities most recently settled and into them have moved young couples with children. The old people constitute a higher percentage of the population in the areas near the business center of the city. A few of these areas have as high as 12 or 13 percent of the population who are 65 or older. These areas are the old part of the city. In the better class old areas old people live in homes which they have lived in and owned since their youth. Near the business center are also the rooms and flats over stores and the large homes converted into light housekeeping rooms where rents are low. Into these quarters move the old people whose income is low. Three or four families may share one bathroom and many of the old houses do not have central heating. Some of the old people who have never had a high standard of living are content and happy; for others who at one time lived comfortably but now have a small income the change has brought bitterness and resentment. Other old people live in hotels or in rooming houses near the center of the city, where they are conveniently near restaurants, stores, and motion picture houses. Rockford requires an inspection by the Health Department of all rooming houses which cater to six or more roomers. There are ninety rooming houses in Rockford, most of them within two-thirds of a mile of the central business district. Not all of these rooming houses serve old people, but some include a few old people and others are operated especially for them, with the landladies providing meals as well as rooms and a certain amount of care in case of illness. Some of these rooming houses and boarding homes that cater to the old charge as much

[3] National Resources Planning Board, Human Conservation, the Story of our Wasted Resources: Government Printing Office, Washington, D. C., 1943, pp. 92-93.

as $125 per month; others will accept the amount received by old-age pensioners, averaging $41 per month. The old people who are scattered throughout the residential districts live in their own homes, with their children, or in private families that take only one or two roomers and hence are not included in the official list of rooming houses with six or more roomers.

The problem of housing for old people is revealed only partly by a study of the communities where they tend to congregate. The prevalence of chronic illness among old people has been mentioned. Chronic illness and the general enfeeblement that comes with advanced years create a special housing problem, for here is a group unable to live independently and at the same time not sufficiently ill to become hospital patients. Some of these ailing old people are cared for by adult children; others have no children; in other cases the complications of adapting a normal family life to the demands of a chronic invalid have become so great that continued care in the home of a son or daughter threatens the integrity of the family. Finances are also a complication, because the income of those on Old-age Pensions is low even though the state makes additional grants to those in need of physical care. No comprehensive planned attempt has been made in Rockford to provide for old chronic invalids. Nevertheless, various institutions have developed out of the evident need, or already existing institutions have adapted themselves to some degree to provision for chronic invalids. The institutions that help to meet the need fall into five types.

1. The County Farm does not limit its service to old people, but the old constitute most of the clients. The County Farm has four divisions. The division known as the Farm Home houses 45 people, including old people who have not yet reached the age of 65 when they are eligible for Old-age Pensions and those who for some other reason are not eligible. A convalescent ward cares for 42 people and there is a plan to increase the capacity to 100; this ward is planned for the chronically ill and caters for the most part to the old. There is also a hospital which can give care to 65 acutely ill persons; these are not all old. A small contagious ward is also operated in connection with the County Farm, but we are not concerned with this ward as few old people contract contagious diseases. When anyone enters the County Farm he must be a client of township relief; this means that when an old-age penssioner enters he gives up his pension from the State. When married couples enter the Farm Home they are placed in separate men's and women's wards.

There is some agitation in the community to induce the county board of supervisors to convert the Farm Home into a home for chronic invalids, most of whom of course would be old people. The State of Illinois now makes provision for county farms to convert to hospitals for chronic cases and receive payment for their clients from Old-age Pension funds of the State. The county must bring the physical equipment and personnel of the in-

stitution up to a given standard and meet certain standards of care. The State then pays a sum previously agreed upon for each old-age pensioner who finds it necessary to enter the institution. At present when old people on pensions enter the Farm Home they become clients of township relief. In some counties the county farms had closed when their clients left to receive pensions and live independently. The effect of the law was to induce counties to re-open their county farms and to modernize them. The Winnebago County Farm did not close and is now handling as many persons as it can. If a conversion was made the effect would be to provide care for more chronically ill and to assure a larger proportion of the income of the Farm from the state pension funds rather than from township funds. At the same time, other provisions might have to be made for any persons in the Farm Home not chronically ill or not eligible for the State Old-age Pension.

2. The second type of institution serving chronically ill old people is the private nursing home. These homes are operated as a business venture by women who make a living by caring for old people. There are at least six such nursing homes in Rockford, located in large old houses. A local ordinance provides for inspection of these nursing homes by the Health Department. The inspection covers all types of sanitation, l i g h t i n g , ventilation, heating, care of food, number and types of nurses, and records kept. Fire safety provisions must also be met. It is extremely difficult for most of these nursing homes to meet the requirements and at the same time keep the fees charged low enough to make it possible to give care to the low income group. There is a tendency to subdivide rooms sometimes only by partitions which run part way to the ceiling and to place several persons in one room. The operators of some of the homes meet criticism of the physical aspects by calling attention to the limited needs of the old and by emphasizing the response of their patients to sympathetic personal care. A few of the nursing homes charge higher fees and have more adequate facilities.

3. There is one small private hospital whose patients are mostly old persons who are chronic invalids. This hospital is organized as a nonprofit institution and caters to about 25 people. Standards are high and it is well administered.

4. The fourth type of institution does not specifically solicit chronically ill persons but by nature of the service given provides for many who are chronically ill. There are three privately f i n a n c e d institutional Homes in Rockford caring for a total of about 150 persons, not all from Rockford, however, as the largest of the three Homes serves the entire state. Each of these Homes has its own entrance requirements. One serves only those affiliated with a lodge; another only those of one nationality background; two have entrance fees. All three require that the resident be in good health at the time of entrance; but once accepted the resident is assured of adequate care t h r o u g h whatever illness may develop. Hence these Homes have a number of chronic invalids.

Very few of the residents of these Homes are men and none are married couples.

5. The fifth type of institution that serves the chronically ill old person is the general or special hospital which serves all classes of the population, the old included. Rockford has three general hospitals, a private mental hospital, and a municipal tuberculosis sanitarium. Each of these institutions has its quota of the old, and although the general hospitals dislike to take chronic cases because of the demand for facilities for acute cases they are not always able to avoid it.

As we put together the various bits of information on housing and correlate them with the types of old people in the population, the two most acute needs not well met are sufficient care for the chronically ill and feeble old persons, and better provision for those still able to carry on alone but who are on Old-age Pensions or have other small incomes not large enough to provide comfortable living quarters. There is also need for better provision for old couples. The classes of old people best provided for in the matter of housing are those with adequate private incomes, those cared for by their adult children, and those in institutional Homes.

Old people typically have more time than they know how to fill satisfactorily. Old men especially, after retirement, have unfilled days. Old women are in a similar position if they have been employed, if they enter a Home for the old, and often if they become members of a son's or daughter's household. The situation is complicated by the lowered income of many of these people after retirement and also by decreasing strength which makes an expansion of activities difficult. The typical picture is of the old person sitting around or aimlessly puttering at almost useless jobs or restlessly getting into other people's way in trying to help. As age increases, it becomes more difficult for the old person to travel about the city alone, and he drops first one type of contact and then another. If he cannot afford to pay dues or put money in the collection plate at church he drops out of organized groups soon after retirement. The need for activities is not met in any definite manner in Rockford—in fact it is scarcely recognized as a need. Some community agencies more or less incidentally supply old people with occupations. This situation is true of the Goodwill Industries, whose function is to rehabilitate handicapped workers. At least during the war period when private employment was plentiful, most of their workers were over 60 years old. In a period of industrial expansion, as during the war, many industries employed old people, although none of the industries where interviews were held had a policy of employing old people. Some of the industries give recognition at company dinners to employees who have been with the company for long periods of time. After retirement securing of paid employment is a matter for individual effort—no agency takes the initiative in helping old people find jobs. Likewise, no agency was found that definitely had a plan for helping old people find unpaid occupations. Four enterprising old men regularly gave

volunteer work to the ration board during the war, but the initiative came from one of the old men who volunteered his services and brought in three friends. A sampling of churches did not reveal any effort to provide organizations for old people, although some churches more or less incidentally had organized activities that appealed to old people. In one church, for instance, a thriving Red Cross sewing group provides both productive work and a social outlet for a group of elderly and old women, but it was not begun with the idea that it would appeal to these women. There are no specifically old-age clubs, such as the Borrowed-Time Clubs or Three-quarter Century Clubs found in some cities. Retired teachers have a club. Other old people are in clubs which they, as young persons, organized and which now are old people's clubs by virtue of the passage of time and the failure to take in new and younger members. The settlements and community houses in the city have no special activities for the old, although the old are able to participate if they wish in the general activities for adults. Also the lodges, and men's and women's clubs and civic or social organizations have their contingent of members who have grown old. Although one often hears it said that old people should not be herded together into groups but should participate with younger people, nevertheless we also have to recognize that often they are pushed aside in younger groups and have no opportunity to serve as officers, on committees, or actively in providing programs. In their own organizations they may set their own pace and exercise initiative and authority. It seems that some of the outlets of old people should cater specifically to their interests and be limited to their abilities.

For those who live into the later years and for many with chronic handicaps different types of occupation and recreation are needed—those that can be brought to the old person at home or which can be carried out in the immediate neighborhood. There is no provision for such activities on a community basis. The nursing homes and institutional Homes do very little, although most of them provide for holidays, birthdays, and other special occasions. Sometimes groups from the community go in to sing or entertain. While this type of effort provides entertainment or amusement it is not of the type to give the old person the satisfaction of participating in an activity himself, or creating or producing something. In the institutions that were visited (several of them a number of times) the old people seemed to spend most of their time in their own rooms, behind closed doors, listening to the radio, reading, or in other solitary pursuits. This isolation was not because of any pressure from those in charge of the institutions. It arose in part because of a desire for quiet, but also because of a lack of provision for interesting group activities. In time, old people become habituated to isolation and solitary activities and develop ingrown and egotistical personalities which make it difficult for them to maintain satisfactory social contacts.

The problem of participation in groups outside the house is acute for

many old people. In one Home many old people were housebound unless someone called for them in a car or a matron took them in a car as the Home is several blocks from the bus line and there is no sidewalk. Even the residents of a Home near the center of the city were housebound in winter unless some friend came for them, because they feared to venture on the icy sidewalks. Those in their own homes may also be isolated. One woman whose foot dragged because of a stroke several years before had not been out of her basement apartment for five months during the winter because she was afraid she would fall on the slippery walks. Her only human contact was the daily one with a dull and slightly demented husband.

A less obvious need of old people in Rockford as elsewhere, is for intimate companionship and affection. As physical strength declines, self-confidence also declines, and the need for a protective love increases. The assurance of physical care relieves many of the anxieties of old people, but it does not take the place of personal affection. The old couple is most happily situated for each has the companion of many years standing, to love and be loved by, to quarrel with and to make up with, each understanding the peculiarities and appreciating the good qualities of the other. When the old person is left as a widow or widower the first thought of family, friends, and community agencies is to provide good physical care. The conception of good physical care held by a younger member of the family or by the community may involve moving the old person from his home and perhaps from his neighborhood or city. This involves still further loss of intimate relationship, for the old person is then separated from his friends. If the old person becomes a member of the household of a married son or daughter, he may find a family circle that is complete without him and he may never feel completely a member of the family. There are times when it is better for an old person to move in with another companionable old person or into an institution than to live with a son or daughter but not be a member of the family circle. The old person will at least find someone of his own age in the partnership with another old person or in the institution, and he will expect less affection than from his own family and therefore feel less tension if relationships remain on an impersonal basis. As people become very old and more helpless it is important for them to have a sympathetic, somewhat younger person to whom to cling who will give assurance of continued loving care. This person may be a member of the family, or may be a nurse or attendant. The loneliness and detachment of old people are greater in a city than in small towns, for there is less neighborliness and therefore less concern of people for one another.

Finally, we come to a consideration of the personal happiness of old people and the personal disorganization which may result when unhappiness is long continued and there is no prospect of future happiness. Drastic changes normally cause some disorganization and unadjustment at whatever age they come. When the child first enters kindergarten, when the adolescent becomes a col-

lege student, when the youth secures his first job, when the young adult marries, there is a period of uncertainty and doubt. But usually these changes have prospects of increased pleasures to offset the temporary disturbance. Deaths, unemployment, illnesses, disappointments in love and in ambitions come also to the young; but again they may be offset by other values or they may disturb only one area rather than many areas of life. And the young look into the future and adjust to the difficulties of the present. The old person is in a different situation. In the first place, many of the changes are permanent in character: retirement is permanent unemployment; illnesses are likely to be chronic rather than brief; widowhood holds little future promise of remarriage. In the second place, the changes of old age are likely to be cumulative: retirement means lowered income, which in turn means lowered social status and a giving up of many activities and luxuries; or death of a husband means not only loneliness but loss of income and perhaps the inability of the old widow to continue in her own home. Even when changes are not related to each other, they seem to come to the old with only brief intervals between. The person over 65 must accept the prospect of unemployment, lowered income, deaths of family and friends, decreased vitality, and increased and perhaps chronic illnesses. These many and drastic changes that come to the old are not offset by the prospect of future gains. In general the world of the old is a contracting one with an ever shortening and more dreary future. It is not surprising therefore that many old people are irritable, quarrelsome, and inclined to criticise others for their unhappiness; or that others are self-centered and take refuge in pains and aches or try to dominate those about them; or that others are torn by fears and anxieties beyond any reasonable degree. In our contacts with old people in Rockford, these and other symptoms of unhappiness and maladjustment were found. A few cities in the United States have established consultation centers for old people, where old people or those concerned for their welfare may go to talk over their problems and receive advice as to special agencies that may help them. Rockford does not have such a center, although there is some tendency for people to go for general advice to the staff of the Division of Public Assistance, which administers Old-age Pensions, as well as to make applications for pensions. The policewomen of Rockford also find that old people, men and women, come to them for advice and reassurance, especially when they feel that someone is imposing upon them. Some ministers attempt to keep in touch with old people even after they are no longer able to attend church. But other ministers center their attention upon the young and are blind to the needs of the old; and some ministers who call upon the old have developed techniques for keeping their calls short and formal, thus forestalling the flood of repressed grievances that might pour forth. The social agencies proper, that are concerned with personal and social adjustment, tend to concentrate their attention upon the young, for in them they see the

threat to future community welfare and the prospect of improvement. The experience in other cities has shown that many old people may be helped both to find more satisfactory living arrangements and activities and thus decrease their dissatisfactions and to readjust their attitudes toward themselves and others so that they will more gracefully accept the increasing limitations of old age. It is true, of course, that some of the old who are unadjusted cannot be helped. Senile dementia claims some of the old. In Rockford, as in most communities, serious cases of senile dementia find their way to the state asylums, and mildly disturbed people are accepted in some of the local nursing homes. What is not clearly understood is that there is a wide twilight zone between well developed senile dementia and normality, a zone of unhappy and slightly disturbed old people whose problems might be solved by reorganizing their activities and helping them to readjust their attitudes.

In conclusion, the conditions and problems of old people in Rockford (and in other cities) may be listed:

1. In 1940, persons aged 65 and over equalled 7.6 percent of the population of the city and 7.0 percent of the suburban population.

2. The proportion of the old that is foreign-born is three times the proportion in the general population that is foreign born.

3. The foreign-born equal 45 percent of all old people: Negroes represent only 0.7 percent of the old.

4. Old age, running from 65 to 100 years, is a long period. The younger group in general is able-bodied, active, and often employed; the middle group usually is not employed and has reached a period of limited activity; a small, older group requires personal care.

5. Women exceed men, especially in the older age brackets. For age 85 and over, 60 percent of the group are women.

6. Widows and widowers become an increasing proportion of the old age group with each five-year period. For the oldest group, aged 85 and over, 84.9 percent of all women and 65.3 percent of all men are widowed.

7. Sixty-five is coming to be accepted as the age for retirement, although in a prosperous period such as the war period, many work until age 70 or even longer. Retirement brings problems of support. In Rockford about 13 percent receive Old-age Pensions and about 25 percent receive Social Security benefits. Others continue to work, live on their savings, receive pensions as public or industrial employees, or are supported by their sons and daughters. The number falling into these classes is not known.

8. The amount of ill health and the number of serious physical handicaps are not known but surveys in other communities indicate that physical disabilities of all kinds are common among old people.

9. Old people in Rockford tend to congregate more heavily in areas near the business center than in outlying communities. Some live in comfortable homes but others are living in rooming houses, light-housekeeping rooms, or hotels.

10. The chronically ill present a special problem of housing and care. Rockford has a variety of facilities but is inadequately prepared to care

for the feeble and chronically ill with low incomes. The provisions include the County Farm Home and the convalescent ward of the County Hospital, one small private hospital that caters to the old, a half dozen private nursing homes with varying fees, and the facilities of the hospitals that serve all classes of the community. Institutional Homes care for about 150 old people, some of whom have become physically disabled after entering the Homes.

11. Among all types of institutional care little provision is made for old couples, who find themselves either not accepted in the institutions or are compelled to live in separate men's and women's wards.

12. Old people are left to find occupations and recreation as best they can, either in clubs and organizations to which they have belonged since earlier years or in activities not planned especially for the old but which happen to appeal to them. Almost no attention is given in the community to old people who are unable on their own initiative to find satisfying activities.

13. Many old people are unable to leave their homes or immediate neighborhoods. Unless families or friends are able to take them out they spend weeks and perhaps months without outside contacts.

14. Many old people are unable to adjust without aid to the many changes that come in old age and to the prospect of continued ill health and restrictions in activities. Although various community agencies give these old people some guidance there is no agency that accepts this work as a special function.

15. Finally, the problems of the old in Rockford are probably the problems of the old in any small industrial city; its facilities for their care are probably equal to facilities elsewhere; and its slow awakening to the needs of the old is no doubt typical of many communities.

A BASIC DEFECT IN THE ILLINOIS CONSTITUTION

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The government of the State of Illinois is today functioning under a constitution adopted in 1870. In spite of eight amendments, the last of which was adopted in 1908, there has been an increasing amount of dissatisfaction with our State Constitution. The recognition of the need for far-reaching and numerous changes had become so widespread that in 1920 a constitutional convention was called. The fact that the results of that convention were not approved by a majority of the voters at a special election called in 1922 does not mean that the need for change has diminished. On the contrary, the inadequacies of the present Constitution have become increasingly apparent as the years have passed.

It is not my intention here to make any item by item analysis of the present Constitution, nor to propose specific changes in the various articles. Many analyses have already been made of specific aspects of that Constitution, pointing to defects in such matters as the amending procedure, the judicial organization of the State, the revenue system, the organization of the executive branch of the State government, and the provisions for local government. Rather than to repeat those analyses—a repetition which could only be superficial in a brief address—I wish to call your attention, in this paper, to what I consider to be a basic defect of the Illinois Constitution. The point I should like to make might be introduced by the question: Why should the present Constitution be so thoroughly criticized, so generally unsatisfactory in so many of its provisions, unless there be some basic defect?

Much that has been written and said on behalf of a need for constitutional revision in Illinois implies that the basic defect is the age of the present Constitution. It is easy to point to the fact that the Constitution was adopted seventy-seven long years ago, and that it was intended to operate in an agricultural state populated by a meager two and a half million instead of in an industrialized state with a population approaching eight million. And now we have the atom bomb to make the contrast even more striking. All of these points are true, but I think it is gross error to assume, without further inquiry, that a constitution is inadequate, out-dated, and defective merely because it was drafted and adopted with reference to economic, social, and political conditions which have since undergone fundamental changes.

Let us for a moment make some comparisons between the Illinois and United States Constitutions. If one is old, the other is much older. Seventy-seven years is young contrasted to the one hundred and fifty-eight year age of the Constitution of the United States. While the population increase during the life of the Illinois Constitution has been threefold, the population increase during the life of the Federal Constitution

has been almost fifty-fold, or from three to one hundred and forty million. And need I do more than to hint at the far greater economic, social and political changes that have taken place in the United States in the last 158 years than have developed in the state of Illinois in the past 77 years? In spite of these contrasts the Federal Constitution has been better adapted to modern problems than has the Illinois Constitution. One cannot justifiably say that this better adaptability is due to the character or greater number of amendments to the Federal Constitution. While it is true that there are technically twenty-one amendments to the Federal Constitution as against only eight to the Illinois Constitution, yet it must be realized that only a few of the twenty-one amendments have any significant bearing on the problem of adjusting the Federal Constitution to changing economic, social and political conditions. For our purposes here the first ten amendments may be disregarded because they were adopted in the early 1790's under circumstances which indicate that the people of those times considered them an integral part of the original Constitution. Of the remaining eleven amendments only five can be regarded as having been prompted or necessitated by economic or social changes. These five are the three civil war amendments, the 16th amendment which cleared away an obstacle to the adoption of an income tax by the Federal Government, and the 19th amendment which extended the suffrage to women. But the subjects of these amendments involve only a microscopic few of the many phases of American life which have undergone great change. It is safe to conclude that the amendments to the Federal Constitution have contributed only slightly to the great task of adapting that Constitution to modern conditions.

The comparison I have been making ought to demonstrate amply that the mere age of a constitution is not in and of itself a defect. The comparison hints, furthermore, at what I regard as a fundamental defect of the present Illinois Constitution. That defect is that the Constitution is too long and too rigid. The Illinois Constitution is not flexible and adaptable to changing conditions. In that respect it differs greatly from the Federal Constitution. It should be emphatically noted that a well drafted constitution will contain no more than the bare essentials, the fundamental features, with respect to the organization and powers of the government to be established. Further than the fundamentals it should not go. Therein lies a vital defect of the Illinois Constitution. It contains more than the bare essentials. It contains much that is properly of a legislative level, not of constitutional importance. It is not without significance that whereas the Federal Constitution as amended contains roughly 7,500 words, the Illinois Constitution requires approximately 25,000 words.

A few illustrations will demonstrate the defect I am describing. Article XIII, which deals with public warehouses, provides in section 2 that:

> The owner, lessee or manager of each and every public warehouse situated in any town or city of not less than 100,000 inhabitants, shall make weekly statements under oath, before some officer

to be designated by law, and keep the same posted in some conspicuous place in the office of such warehouse, and shall also file a copy for public examination in such place as shall be designated by law, which statement shall correctly set forth the amount and grade of each and every kind of grain in such warehouse, together with such other property as may be stored therein, and what warehouse receipts have been issued, and are, at the time of making such statement, outstanding therefor; and shall, on the copy posted in the warehouse, note daily such changes as may be made in the quantity and grade of grain in such warehouse; and the different grades of grain shipped in separate lots shall not be mixed with inferior or superior grades without the consent of the owner or consignee thereof.

Notice the unnecessary rigidity of this section. And subsequent sections of the same article contain provisions equally definitive. Such details have no place in a constitution. They are essentially legislative, not constitutional in character. It is not, I submit, basically essential for the effective and satisfactory functioning of government in Illinois that the provisions of this article apply only to cities with more than a 100,000 population; nor that statements under oath be made every seven days; nor that daily changes be noted. Such specific requirements in a constitution prevent the legislature from adjusting the operations of the government to meet the main purpose of the article. The objective was to prevent the issuance of false and fraudulent warehouse receipts and to protect producers and shippers from such falsification and fraud. Yet from the way in which the article was drafted with all its detail the legislature could not without constitutional amendment have extended like control to prevent fraud on the part of the operators of public warehouses in cities with a population under 100,000. Also, without further amendment the state legislature could not properly provide for quarterly instead of weekly statements from public warehouse operators even though it were realized that weekly statements were u n d u l y burdensome on business and unnecessary for the purpose of the regulation. A person would seriously be considered a fit inmate for an insane asylum were he to propose that the Federal Constitution be amended so as to provide for a bi-weekly report to the Interstate Commerce Commission of the total volume of business done by all common carriers engaged in interstate commerce.

Criticism of a similar nature may be made of provisions in the Illinois Constitution on the subject of local government. Every county in the State is constitutionally required to elect a county judge, a county clerk, a sheriff, a treasurer, a coroner, and a clerk of the circuit court. In addition those counties which have not chosen to organize on a township basis are required to elect a board of three members to be known as the Board of County Commissioners, part of whose authority is defined in the constitution. In addition the management of the county affairs of Cook County are constitutionally vested in a board of fifteen, two-thirds of the board to come from within and one-third to come from without the city of Chicago. It should be obvious that provisions such as these prevent the legislature and the people of Illinois counties from taking full advantage of the experience and experiments of other

states in the matter of improved county organization. In New York City and some other jurisdictions, for example, it has been found that a Chief Medical Examiner who is appointed and under civil service is far more satisfactory than the ancient office of Coroner, which it has replaced. In order for an Illinois county to profit by that experience it would first be necessary to eliminate the elective office of the coroner by a constitutional amendment.

One further illustration of constitutional rigidity in Illinois may be noted in the constitutional requirement that in the executive branch of the State government the following officers must be elected: the Governor, the Lieutenant Governor, the Secretary of State, the Attorney General, the Treasurer, the Auditor of Public Accounts, and the Superintendent of Public Instruction. This election system means that these officers are in an autonomous position, they may feel themselves responsible to none but the electorate for the operation of their respective departments. This situation permits these officers to direct their departments with a high degree of independence of the Governor, and can even lead to their working at cross purposes with the Governor. Such a condition of non-coordination has existed at times in Illinois to the serious jeopardy of the effective functioning of the State government. Any attempt to remedy it requires a constitutional amendment. It is interesting, in this respect, to note that in 1917 the State of Illinois took the lead in the re-organization of its executive branch. This re-organization took the form of eliminating the autonomous position of many of the existing departments, boards and commissions by bringing them under the guiding and co-ordinating authority of the Governor. It was a governmental improvement that was long overdue in practically every state in the Union. However, the much needed coordination of the executive branch in Illinois had to stop short of the goal desired by some because the legislature was not free to alter the constitutional autonomy of the Attorney General, the Secretary of State, and the few others.

For those who wish to take the time to study the Constitution of Illinois other illustrations than those given above could be found which reveal the tendency of the Constitution to go too much into detail—the unhealthy tendency to clothe matters which properly belong to the level of legislative policy with the rigidity and sanctity of a constitutional status. The adaptability of the government to changing conditions is thus seriously jeopardized. No good executive, whether he be a business man or a public official, would delegate duties to a subordinate and specify in detail the manner in which those duties were to be carried out. He would content himself with outlining the general purpose of the authority he was delegating and leave it up to the subordinate to determine and alter, if necessary from time to time, the means by which that authority was to be implemented. One might legitimately wonder why we don't use the same principles when acting in our sovereign capacity as when acting as good business men.

Unless the present inflexibility of

the Illinois constitution is corrected many of its defective articles will not be satisfactorily remedied. A revised constitution as inflexible as the present one would provide only a temporary improvement. Defects in such a revised constitution would quickly develop as the need arose for changing details. The benefits of a brief and flexible constitution can nowhere be found better revealed than in our own Federal Constitution. The contrast between the Federal and Illinois constitutions in the manner in which many important matters are handled is striking. Whereas the Illinois Constitution in Article VI devotes many hundreds of words to a description of a court system for the state, the Federal Constitution dismisses the subject of the structure of the Federal court system with the following brevity:

> The judicial power of the United States shall be vested in one Supreme Court and such inferior courts as Congress shall from time to time ordain and establish.

If the subject matter of Article XIII of the Illinois Constitution had been handled in the manner used in the Federal Constitution for granting legislative power it would have been condensed to some wording such as this:

> In order to prevent the issue of false and fraudulent warehouse receipts and to protect producers and shippers the Legislature shall have the authority to pass all laws necessary for the regulation of elevators or storehouses where grain or other property is stored for a compensation.

If the powers of Congress over such subjects as interstate commerce, of bankruptcy and coinage of money had been as carefully and thoroughly described as was the power of the state legislature over warehouses the Federal Constitution would have necessitated endless amendments beginning within a few decades of its adoption. In the Federal Constitution the only executive officers named are the President and the Vice President. The departments of the executive branch of our national government have been allowed to develop as the times required. At least in their development Congress has not been hampered by the notions which the framers of the Constitution had in 1787 as regards the number and duties of these departments.

The remarks I have been making on the matter of the essential nature of a constitution and the necessity for conforming to it were well summarized by John Marshall, one of the great Chief Justices of the United States Supreme Court, when he wrote in the important case of McCulloch v. Maryland:

> A constitution, to contain an accurate detail of all the subdivisions of which its great powers will admit, and of all the means by which they may be carried into execution, would partake of the prolixity of a legal code, and could scarcely be embraced by the human mind. It would probably never be understood by the public. Its nature, therefor, requires that only its great outlines should be marked, its important objects designated, and the minor ingredients which compose those objects be deduced from the nature of the objects themselves. That this idea was entertained by the framers of the American Constitution, is not only to be inferred from the nature of the instrument, but from the language.....We must never forget that it is a constitution we are expounding.[1]

And several pages later, in the same opinion, he observed that the American Constitution was

> intended to endure for ages to come, and, consequently, to be adapted to the vari-

[1] 4 Wheaton, 407.

ous crises of human affairs. To have prescribed the means by which government should, in all future time, execute its powers, would have been to change, entirely, the character of the instrument, and give it the properties of a legal code. It would have been an unwise attempt to provide, by immutable rules, for exigencies which, if foreseen at all, must have been seen dimly, and which can be best provided for as they occur.[2]

I sincerely believe that all efforts in Illinois for much needed constitutional improvement will be in vain unless the goal of the ideal constitution—a flexible constitution —is kept constantly in mind. But I would be guilty of leaving you with a gross misunderstanding were I to give you the impression that the task of casting constitutional provisions in broad and general terms while leaving it up to the legislature to fill in the details is an easy one. It is not. There are many opponents to constitutional revision. Their reasons for opposition are important and cannot be ignored. Broadly speaking these opponents fall into two groups. The first group is made up of those who have a personal interest in the preservation of one or more of the rigid provisions in the present Constitution. All people with high incomes and small real property holdings are in a personally advantageous position due to inability of the legislature under the present Constitution to levy a state income tax. They would certainly stand to lose if that position were disturbed. Coroners, whose office is now safeguarded by the Constitution, might well object to a revision which placed the very existence of their office at the hands of future legislatures. I do not wish to imply that all people who might conceivably fall within this first group will be swayed by an imagined personal interest, but there are a great many who will be. And unless this opposition is taken into account it may prove disastrous to reform.

The second group of opponents consists of those who fear that unless grants of power to our government are carefully defined and circumscribed our democratic institutions will be in serious danger at the hands of irresponsible officials who might not properly cherish our institutions. This group of citizens is undoubtedly motivated by a genuine desire to preserve democracy. No one has that desire more than I. But many people in this group are misguided as to how one best preserves democracy. It cannot be done by placing detailed checks on every grant of power. To do that is to defeat the very objective in establishing a government, for it leads to inactive government rather than democratic government. Democratic government cannot exist unless it is a competent government, and that means that grants of power must be ample and not too constricted. The fear of this is, of course, that broad grants of power may lead to abuse. But this is true of any grant of power. The only true protection against the abuse of power by our government lies in the selection of competent officials by an alert and intelligent electorate. In our desire to preserve democracy we must never overlook the fact that in spite of constitutional provisions the great principles of democracy will be maintained only as long as the people have faith in those principles and properly assume their responsibility at the ballot box.

[2] 4 Wheaton, 416.

ZOOLOGY

MILTON W. SANDERSON, *Chairman*
Illinois State Natural History Survey, Urbana

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* 1. The Influence of the Balcones Escarpment upon the Distribution of Amphibians and Reptiles of Central Texas: HOBART M. SMITH, University of Illinois, Urbana. (slides)

* 2. Internal Structure of the Epigynum in Primitive Spiders and its Bearing on Systematics: GILBERT WRIGHT, Illinois State Museum, Springfield. (slides)

3. A Concentration of Lemming Mice *(Synaptomys cooperi)* in Central Illinois: DONALD F. HOFFMEISTER, University of Illinois, Urbana. (slides)

4. Bird Population of an Illinois Floodplain Forest: BEN J. FAWVER, University of Illinois, Urbana. (slides)

* 5. Fish Population of Gale Lake, 18 Months after Severe Winter Mortality: GEORGE W. BENNETT, Illinois State Natural History Survey, Urbana. (slides)

6. Studies of the Sex Organs of Mating Polygyrid Landsnails: GLENN R. WEBB, University of Illinois, Urbana. (slides)

* 7. Animals of Eckert's Cave, Monroe County, Illinois: B. D. BURKS and L. J. STANNARD, Illinois State Natural History Survey, Urbana.

* 8. Quantitative Studies on the Amino Acids of Avian Erythrocytes: ROBERT M. MELAMPY, University of Illinois, Urbana. (slides)

9. Parasites of the Hylidae (Amphibia-Hylinae)—VI: A. C. WALTON, Knox College, Galesburg.

*10. Some Unusual Nuclei Found in the Acanthocephala: HARLEY J. VAN CLEAVE, University of Illinois, Urbana.

11. Major Fluctuations of Some Illinois Mammal Populations: CARL O. MOHR, Illinois State Natural History Survey, Urbana.

*12. Ecology, Taxonomy, and Distribution of *Elliptio complanatus* (Dillwyn) 1817, a Fresh-water Mussell: MAX R. MATTESON, University of Illinois, Urbana. (slides)

*13. Aerial Census and White-tailed Deer Research in Illinois: WILLET N. WANDELL, Illinois State Natural History Survey, Urbana. (slides)

14. The Grooming Dance and Associated Activities of the Honeybee Colony: VERN G. MILUM, University of Illinois, Urbana.

15. Notes and Additional Records of Mammals in Illinois: RALPH M. WETZEL, University of Illinois, Urbana.

16. An Investigation of Some Possible Sources of Trichina Infection in a Central Illinois Community: WAYNE W. WANTLAND and PAUL MARTIN, Illinois Wesleyan University, Bloomington.

*Not published.

BIRD POPULATION OF AN ILLINOIS FLOODPLAIN FOREST

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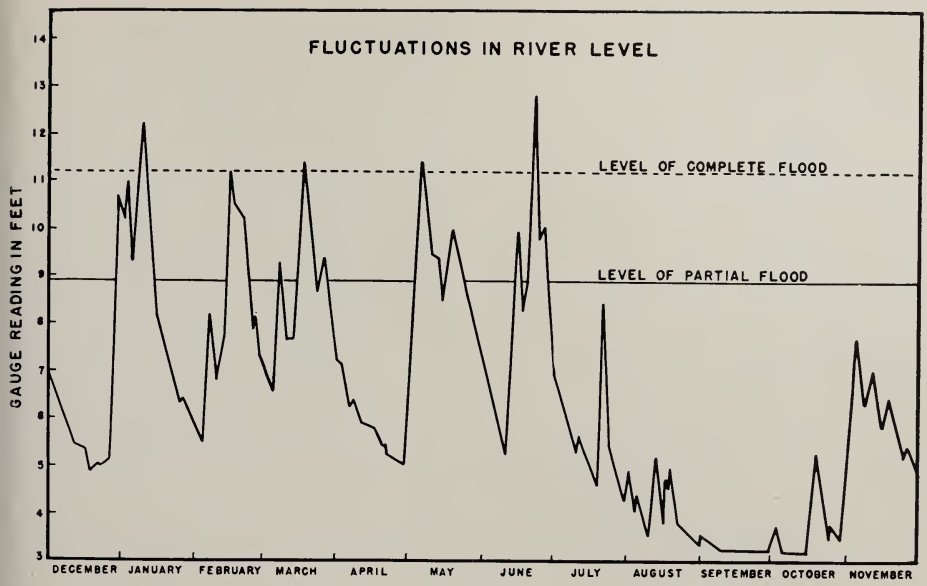
In recent years there has been considerable interest shown in the measurement of animal populations within ecological communities. Such quantitative information is of great service in evaluation of the importance of species within the community and of their habitat requirements. Forbes and Gross (1922) were among the first in this country to determine the bird population of various communities. In 1937, the National Audubon Society began an annual breeding bird census which has stimulated considerable work in this field. Kendeigh (1944) has summarized the history and discussed methods of bird censusing in a recent paper. With the usefulness of some of these newly developed techniques in mind, the floodplain forest was selected as an interesting community for investigation since its distinctive nature had been shown by Shelford (1913).

This paper is based on a study of the birds of a portion of the floodplain of the Sangamon River from March 10, 1946 to March 1, 1947. The area studied is one mile northwest of White Heath, Piatt County, Illinois and about fourteen miles due west of Champaign, Illinois. It lies in Sections 16 and 21 of Township 19 north, Range 6 east. An area of approximately fifty acres was selected for study and some observations were made for comparison over a mile length of the forested floodplain.

The area of study was ungrazed and evidently had not been cut over to any extent. The topography is nearly flat with elevations varying only about six feet. The numerous oxbows and sloughs which are filled with water most of the year account for this variation. According to the Monticello quadrangle of the U. S. Geological Survey, this section of the floodplain lies about 645 feet above sea-level. Since the floodplain is subject to frequent flooding the duff of the forest floor is scanty.

One of the outstanding factors of the physical environment of the floodplain is the periodic floods. The repeated occurrence of flooding is shown in the following graph. Gauge level data were obtained from the Urbana office of the Water. Resources Branch, Geological Survey, U. S. Department of Interior. These gauge readings were taken at Monticello, Illinois, five miles downstream from the area of study. Flood levels were determined by observation of the dates of flooding of the study area. Frequently, river levels were high enough to flood only about half of this area and less often, the tract was totally flooded. This is shown in the graph by horizontal lines at these two levels. From December 1, 1945 to December 1, 1946, the area was totally flooded 15 days and partially flooded 28 days.

It is apparent from these data that the floodplain is a very moist environment. It is interesting to note



that the maximum river level was reached in the third week of June, a time of high nesting activity. Even during the periods of lowest water levels, some of the sloughs contained water and most of the year they all contained some water.

This floodplain forest is characterized by many small openings produced by fallen trees. The number of fallen dead trees, which produce dead stubs and openings in the canopy, is large. The frequent floods also kill much herbaceous growth and large areas are denuded of herbs because of standing water. Such bare portions represented roughly ten to fifteen percent of the area studied.

The composition of the tree canopy was determined by making four transects. Three transects were 3 meters wide and one was 6 meters wide, with the total length equaling 1127 meters. This amounted to 1.3 acres or 2.6 percent of the area. Although this is a rather inadequate sample, it is probably generally indicative. Measurements of the diameter of tree trunks over 2.5 inches were made at breast height with tree calipers. Table 1 shows the data obtained.

Climbing plants constitute a considerable part of the plant structure, both in species and in numbers (tables 3 and 4). These climbers make dense tangles in trees and shrubs as well as in the fallen trees. In openings in the canopy, giant ragweed grow up among the shrubs. Wood nettle is probably the most abundant species of herb in the shaded portions of the area.

Slippery elm and silver maple are the principal dominants of the floodplain (table 1). In drier portions the ironwood, yellowbud hickory, and bur oak form a prominent part of the canopy. Green ash, although not so numerous, forms a conspicuous part of the canopy because of

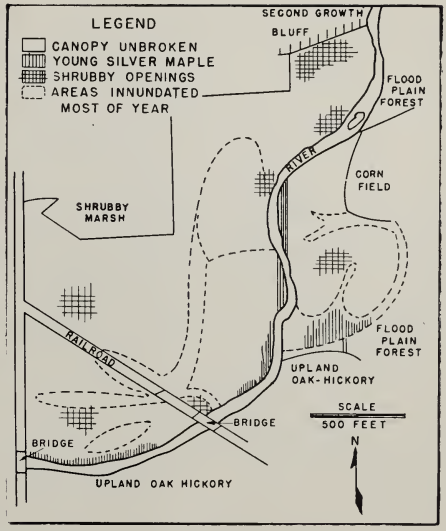
Table 1.—Trees in Various Size Classes

Species	Trees per acre	Percent of individuals in diameter class (Diameter in inches)					
		2.5–6	6.1–12	12.1–18	18.1–24	24.0—	Total
Slippery elm	108	19.4	15.6	7.8	1.6	0.9	45.3
Silver maple	35	4.5	7.1	1.9	.....	1.0	14.5
Hackberry	28	9.7	1.6	.....	0.3	.....	11.6
Green ash	21	1.9	2.9	3.5	.....	0.3	8.6
Hawthorn	12	4.2	0.6	.....	.....	.....	4.8
Ironwood	9	2.9	0.6	0.6	0.3	.....	4.4
Yellowbud hickory	4	0.6	0.6	0.3	.....	.....	1.5
Sycamore	2	.....	.....	0.3	.....	0.6	0.9
Bur oak	2	.....	.....	0.3	.....	0.6	0.9
Lianas (Grape and poison ivy)	12	5.1	.....	.....	.....	.....	5.1
Miscellaneous species	3	0.7	.....	0.6	0.6	0.6	2.5
Total	236	49.0	28.9	15.3	2.8	4.0	

Table 2.—Breeding Bird Population

Species	Number of pairs in the area	Density—number of pairs per 100 acres
Cardinal	9	14
Red-eyed vireo	7	12
American redstart	6	12
Indigo bunting	9	12
Wood pewee	7	12
Black-capped chickadee	5	10
Crested flycatcher	5	10
Downy woodpecker	5	10
Wood thrush	4	8
Yellow-billed cuckoo	4	8
Red-bellied woodpecker	4	6
Acadian flycatcher	2	4
Tufted titmouse	2	4
Barred owl	1	2
Ruby-throated hummingbird	1	2
Hairy woodpecker	1	2
Phoebe	1	2
White-breasted nuthatch	1	2
Carolina wren	1	2
Eastern bluebird	1	2
Prothonotary warbler	2	2
Cerulean warbler	1	2
Scarlet tanager	1	2
Cowbird	present	present
Crow	2	2
Blue jay	present	present
Total	83	144

MAP 1.—Aerial photograph.



MAP 2.—Outline map of area.

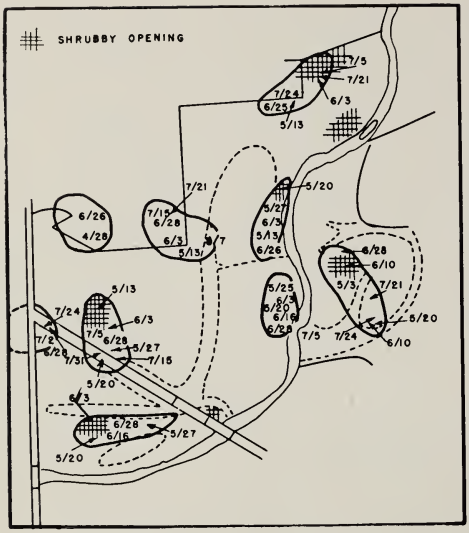
the large size attained by individuals. Sycamores, however, are the tallest and the largest trees in the forest, growing to a height of about a hundred feet. Hawthorn and hackberry form an important part of the high shrub stratum.

The lateral cutting of the river produces areas of deposition on the inside of curves of the streams and causes numerous changes of course of the stream with accompanying oxbows. These areas of recent deposition are characteristically covered by sapling maples (map 3) in nearly pure stands.

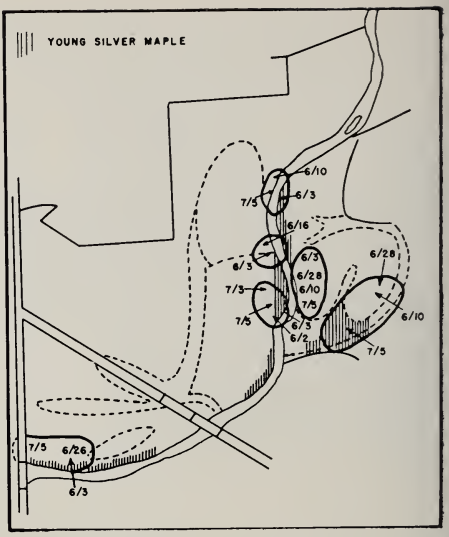
The methods of study were those used by Williams (1936). This consisted of marking the location of each bird seen on a previously mimeographed map of the area. Notes on bird behavior, climatic conditions, vegetation, river levels, and other pertinent information were recorded. Visits were made on the average of once a week. A composite map for each species was then made, as shown in the accompanying maps. Nesting territories can thus be estimated from them.

The species composition, as well as the total numbers of birds varied from season to season (table 6). The breeding population density is shown in table 2, the density being calculated on the basis of pairs per one hundred acres. When the territory of a given pair extended beyond the limits of the study area, it was assigned a value of a fraction of a pair, depending upon the relative amount of use of the territory that extended into the area. This method explains the apparent discrepancy of calculation in the table. For example, there were nine pairs of indigo buntings in the area, but only five had territories wholly in the area (map 3). Hence, the four portions of territories were assigned a value of one pair and the calculated density per hundred acres was twelve pairs.

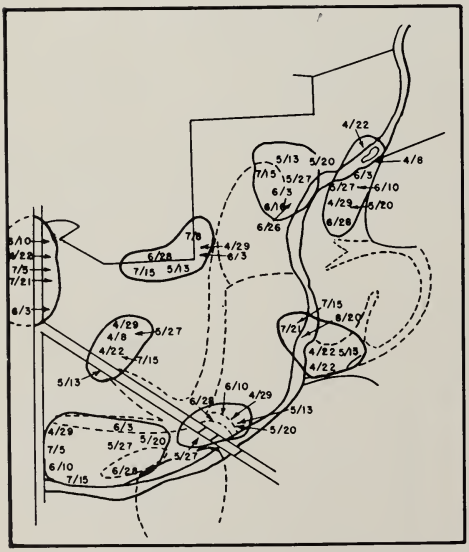
The density of 144 breeding pairs



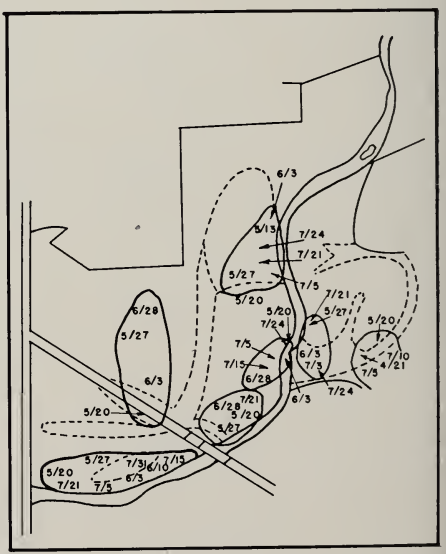
MAP 3.—Territories of Indigo buntings in relation to openings and edge.



MAP 4.—Territories of Redstarts in relation to stands of young silver maple.



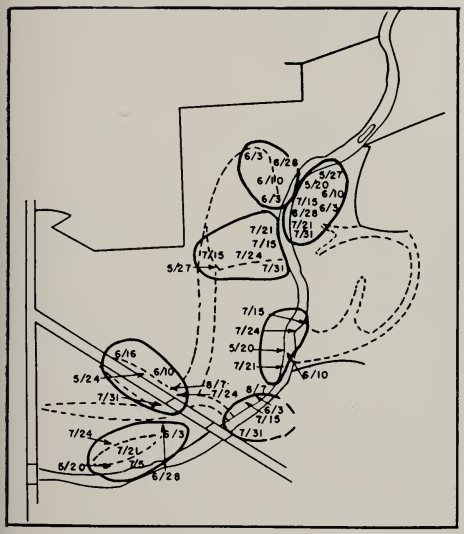
MAP 5.—Territories of Cardinals.



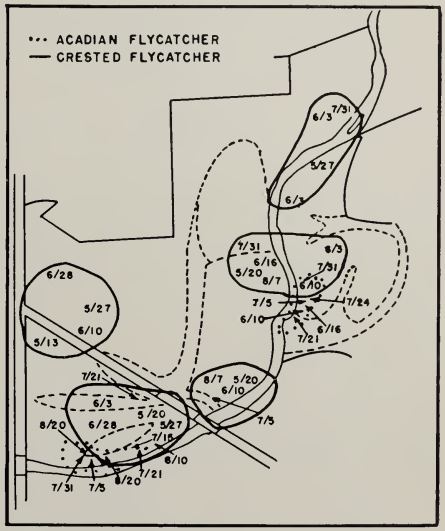
MAP 6.—Territories of Red-eyed Vireos.

per hundred acres compares favorably with that found by Williams (1937) and Deutschlander (1941) in an Ohio floodplain forest. They found 130 and 128 pairs per hundred acres, respectively.

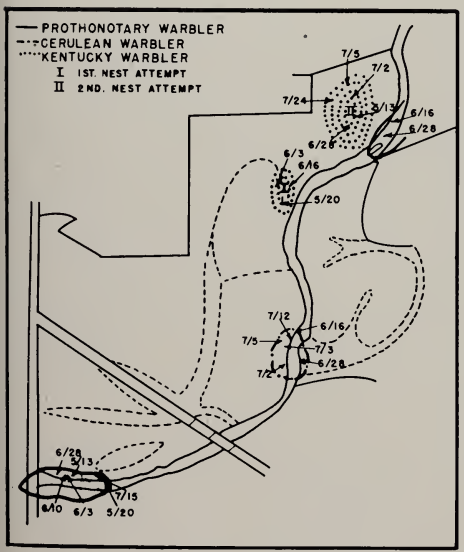
Although quantitative data are insufficient to present here, it was



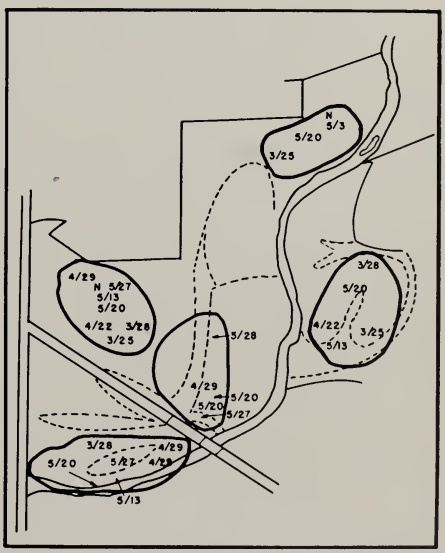
MAP 7.—Distribution of territories of Wood Pewees.



MAP 8.—Distribution of territories of Acadian and Crested Flycatchers.



MAP 9.—Territories of three species of Warblers.



MAP 10.—Territories of Downy Woodpeckers.

apparent that fluctuations in numbers occurred similar to those found by Williams (1936) and Twomey (1945). Permanent residents seemed to remain fairly constant in numbers during most of the year except immediately after the nesting season, when the young birds swelled the

TABLE 3.—WINTER POPULATION
(On the basis of four visits to area)

Species	Average number individuals in area	Individuals per 100 acres
Black-capped chickadee	17	34
Tufted titmouse	14	28
Cardinal	7	14
Downy woodpecker	4	8
White-breasted nuthatch	3	6
Carolina wren	3	6
Flicker	2	4
Hairy woodpecker	2	4
Red-bellied woodpecker	2	4
Barred owl	2	2
Purple finch	2	4
Blue jay	1	2
Brown creeper	1	2
Crow	Fluctuating	
Total	60	118

population for a period of sixty to seventy days during June and July.

One of the most important causes of increase in population was the influx of transients migrating further northward in spring. The population was also swelled by the arrival of the summer residents. It is noteworthy that these summer residents arrived in large numbers and only part of them remained to nest. This was characteristic of such species as indigo bunting, Kentucky warbler, and redstart, which arrived in a big wave the second week in May and only part of their number remained. Likewise, summer residents elsewhere in the region but not nesting on the floodplain increased this spring peak. Such species as the yellow-throat, catbird, and mourning dove were found in the area during the migration period only.

At the end of the nesting period there was a rapid decrease in the size of the bird population, rather than an increase that might have been expected. Such species as the prothonotary warbler and indigo bunting disappeared entirely from the area. It is interesting to note that in this same period there was an influx from elsewhere of immature robins, rose-breasted grosbeaks, and catbirds in large numbers. All these species fed voraciously upon the ripening wild grapes in the tree tops. Bronzed grackles, apparently the young of the year, were also seen feeding on the ground in the area. During this time wandering herons and wood ducks were found in the area. The addition of these birds tended to keep the summer population about stable in numbers despite the egress of the nesting residents.

With the coming of autumn, transients and the arrival of winter visitors again swelled the population to a second high peak. By the last of November, the transients and summer residents had left and only the winter visitors and permanent resi-

TABLE 4.—PERCENTAGES OF NESTING PAIRS OCCUPYING DIFFERENT LAYERS IN THREE COMMUNITIES

Type of forest	Beech–maple[1]	Elm–maple[2]	Floodplain[3]
Locality	Ohio	Illinois	Illinois
Layer			
Ground	10.1	2.3	1.3
Tree cavity	15.1	43.6	35.1
Tree canopy	29.4	17.3	16.4
Shrub	45.9	46.8	47.2

[1] Williams, 1936 (4 year average).
[2] Kendeigh, 1944 (11 year average).
[3] Present study.

TABLE 5.—SIZE OF NESTING TERRITORIES

Species	Number of territories measured	Average observed (Size in acres)	Maximum acreage available per pair
Cardinal	7	2.7	7.1
Red-eyed vireo	6	3.1	8.0
American redstart	6	1.4	7.7
Indigo bunting	6	2.2	7.5
Wood pewee	6	2.9	8.0
Black-capped chickadee	5	2.1	10.0
Crested flycatcher	5	3.1	10.0
Downy woodpecker	5	4.7	10.0
Yellow-billed cuckoo	3	2.5	12.5
Wood thrush	2	4.7	....
Red-bellied woodpecker	3	6.1	17.0
Tufted titmouse	2	4.0	....
Acadian flycatcher	2	1.7	....
Kentucky warbler	2	1.1	....
Prothonotary warbler	1	1.6	....
Cerulean warbler	1	1.3	....
Bluebird	1	3.5	....
Carolina wren	1	7.5	....
White-breasted nuthatch	1	5.7	....
Phoebe	1	0.7	....
Barred owl	1	40.0	....

dents remained. The winter visitors to the floodplain are small in numbers and species, as shown in table 3.

An outstanding and obvious influence of the river is affected through its repeated inundation of the floodplain. The first nesting attempt of one pair of Kentucky warblers was flooded out (map 9). It is noteworthy that the season of highest flood, both for the year of study and also for the previous year, occurred in June when most species of birds were nesting. Only 1.2 percent of the population are ground-nesting birds (table 4). This is low compared with upland communities and is probably a result of flooding. The oven-bird, one of the most abundant nesting species of the deciduous forest (Kendeigh, 1944), is conspicuously absent from the breeding pop-

ulation of the floodplain forest. Since this species nests on the ground, flooding doubtless prevents its nesting in this community; why nesting attempts are not made is open to speculation. The small layer of duff on the forest floor and the wet soil may be factors.

The indigo bunting was the only other low nesting species that could have been affected by floods. Dambach and Good (1940) found that indigo buntings were the only herb-shrub nesting species in a grazed woodland; grazing would have the same effect as flooding on ground-nesting species.

The flycatchers exhibited a decided preference for the forest edge along the river (maps 7 and 8). Gates (1911) also found this in a study of birds in a floodplain forest near Havana, Illinois. Since the river offers an open expanse of air for feeding, bordered by perches of various heights, such a situation is an ideal habitat for this group. Apparently it is the sharp transition from forest to open without gradual decrease in tree and shrub height that is important since the railroad offered a similar habitat niche and was utilized in a similar manner. The road also provided a suitable situation for at least one pair of wood pewees just outside the area of study. This theory is further substantiated by the fact that the flycatchers did not utilize the field and marsh edges which were characterized by a gradual transition in height from tree, shrub, to open area.

The importance of the river as a barrier was entirely negative. The width of the river is only about thirty feet, and, consequently, is not wide enough to be an obstacle to birds. Such species as the cardinal, cerulean warbler, and wood pewee defended territories that extended on both sides of the river. Birds were seen crossing the river at all seasons and often. The boundaries of some territories coincided with the river, but this was probably a response to the forest edge along the stream as a habitat niche rather than a barrier as the same species frequently used both sides of the river in one territory. Such species as the cardinal and wood pewee exhibited this behavior (maps 5 and 7).

The river and oxbows offered a supply of food to the kingfishers and herons. A kingfisher evidently nested in a river bank about 100 yards upstream from the area and fed regularly in the area along the river. Great blue herons, green herons, and black-crowned night herons fed in the tract all during the months of July and August. One immature black-crowned night heron spent several days in the vicinity of a drying slough, feeding on trapped minnows there.

During July and August the river was used as a watering and bathing site by the large influx of robins and rose-breasted grosbeaks, and it was doubtlessly important to other species as a source of water.

The forest edge along the river is the characteristic habitat of the prothonotary warbler. In central Illinois this species is confined to the larger stream valleys (Loucks, 1895).

The close relation of nesting indigo buntings to edge has been shown by Kendeigh (1944). A

TABLE 6.—BIRDS OF THE AREA—SEASONAL GROUPS

Permanent Residents

Barred owl, *Strix varia*
Red-bellied woodpecker, *Centurus carolinus*
Hairy woodpecker, *Dryobates villosus*
Downy woodpecker, *Dryobates pubescens*
Blue jay, *Cyanocitta cristata*
Crow, *Corvus brachyrhynchos*
Black-capped chickadee, *Parus atricapillus*
Tufted titmouse, *Parus bicolor*
White-breasted nuthatch, *Sitta carolinensis*
Carolina wren, *Thryothorus ludovicianus*
Cardinal, *Richmondena cardinalis*

Summer Residents

Red-shouldered hawk, *Buteo lineatus*
Yellow-billed cuckoo, *Coccyzus americanus*
Ruby-throated hummingbird, *Archilochus colubris*
Belted kingfisher, *Megaceryle alcyon*
Crested flycatcher, *Myiarchus crinitus*
Eastern phoebe, *Sayornis phoebe*
Acadian flycatcher, *Empidonax virescens*
Eastern wood pewee, *Myiochanes virens*
Wood thrush, *Hylocichla mustelina*
Red-eyed vireo, *Vireo olivaceus*
Prothonotary warbler, *Protonotaria citrea*
Cerulean warbler, *Dendroica cerulea*
Kentucky warbler, *Oporornis formosus*
American redstart, *Setophaga ruticilla*
Cowbird, *Molothrus ater*
Scarlet tanager, *Piranga olivacea*
Indigo bunting, *Passerina cyanea*

Autumn and Winter Visitors

Flicker, *Colaptes auratus*
Brown creeper, *Certhia familiaris*
Slate-colored junco, *Junco hyemalis*
Tree sparrow, *Spizella arborea*
Purple finch, *Carpodacus purpureus*

Transients (Autumn and Spring)

Whip-poor-will, *Caprimulgus vociferus*
Yellow-bellied sapsucker, *Sphyrapicus varius*
Olive-sided flycatcher, *Nuttallornis borealis*
Red-breasted nuthatch, *Sitta canadensis*
Winter wren, *Troglodytes troglodytes*
Hermit thrush, *Hylocichla guttata*
Olive-backed thrush, *Hylocichla ustulata*
Gray-cheeked thrush, *Hylocichla minima*
Golden-crowned kinglet, *Regulus satrapa*
Ruby-crowned kinglet, *Regulus calendula*
Warbling vireo, *Vireo gilvus*
Black and white warbler, *Mniotilta varia*
Golden-winged warbler, *Vermivora chrysoptera*
Magnolia warbler, *Dendroica magnolia*
Myrtle warbler, *Dendroica coronata*
Black-throated green warbler, *Dendroica virens*
Chestnut-sided warbler, *Dendroica pennsylvanica*
Palm warbler, *Dendroica palmarum*
Oven-bird, *Seiurus aurocapillus*
Canada warbler, *Wilsonia canadensis*
Rusty blackbird, *Euphagus carolinus*
White-throated sparrow, *Zonotrichia albicollis*
Fox sparrow, *Passerella iliaca*

Occasional Visitors

Great blue heron, *Ardea herodias*
Green heron, *Butorides virescens*
Black-crowned night heron, *Nycticorax nycticorax*
Wood duck, *Aix sponsa*
Turkey vulture, *Cathartes aura*
Cooper's hawk, *Accipiter cooperi*
Red-tailed hawk, *Buteo jamaicensis*
Bob-white, *Colinus virginianus*
Coot, *Fulica americana*
Mourning dove, *Zenaidura macroura*
Red-headed woodpecker, *Melanerpes erythrocephalus*
House wren, *Troglodytes aedon*
Catbird, *Dumetella carolinensis*
Brown thrasher, *Toxostoma rufum*
Robin, *Turdus migratorius*
Cedar waxwing, *Bombycilla cedrorum*
Starling, *Sturnus vulgaris*
Yellow-throated vireo, *Vireo flavifrons*
Water-thrush, *Seiurus noveboracensis*
Yellow-throat, *Geothlypis trichas*
Bronzed grackle, *Quiscalus versicolor*
Rose-breasted grosbeak, *Pheucticus ludovicianus*
Goldfinch, *Spinus tristis*
Towhee, *Pipilo erythrophthalmus*

similar relation was noted on the floodplain both along the river and also in openings of the forest canopy (map 3). This species prefers shrubby openings for nesting and high posts for singing.

The redstart seemed to exhibit strong tendencies to establish territories in young silver maple stands along the river (map 4). Probably any second growth deciduous trees would have been used either in stands or in edge such as described. Six of the nine pairs of cardinals in the study area used the forest edge made by the river (map 5).

There was a high percentage of shrub nesting species on the floodplain (table 4.). The number of pairs nesting in tree cavities was high and may be the result of large numbers of decaying and hollow trees. The percentage of species frequenting the tree canopy is correlated with the broken and relatively small extent of this layer. The edge effect of the river has been mentioned previously, and this effect is reflected in the fact that 20.2 percent of the breeding population was edge nesting species. Part of these species also nested in openings in the forest and on the edges produced by the field and marsh.

Another factor of importance to population density is that of competition. It seems probable that the strong competition for territory among cardinals was a limiting factor and indicated that this area was becoming saturated with this species. The minimum size to which the territory could be compressed would be of great importance here. The small size of cardinal territories is shown in table 5. Conflict for nesting territory was noted frequently between individuals of such species as cardinals and wood pewees.

An interesting question is raised concerning the competition between species. In several cases, territories of species closely related ecologically and taxonomically overlapped without visible conflict. Such is the case of the wood pewee, crested flycatcher, and Acadian flycatcher (maps 9 and 10). This lack of conflict might be partially explained by the fact that the crested flycatcher occupied the high tree top canopy, while the wood pewee and the Acadian flycatcher stayed in the lower branches of the trees. This segregation to different layers cannot be offered in explanation of the territorial overlaps between downy, hairy and red-bellied woodpeckers which also occurred in the floodplain forest.

Conflict between species did occur, however. This conflict was observed between the red-eyed vireo and the Kentucky warbler and between the wood pewee and the black-capped chickadee. A study of one breeding season, such as this one, only makes such a problem apparent. Further study of such factors would answer many problems in ecology.

The writer wishes to express his appreciation to S. Charles Kendeigh for aid and advice in preparation of this paper.

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A CONCENTRATION OF LEMMING MICE *(SYNAPTOMYS COOPERI)* IN CENTRAL ILLINOIS

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Lemming mice (*Synaptomys cooperi*) have long been regarded as rare in Illinois. Cory, in his report on the mammals of the state, says "So few specimens have been taken in Illinois that we know very little as to its habits in the state." (1912, 236). Even in 1941, Necker and Hatfield, in their account of the "Mammals of Illinois," list only 5 localities for the State from which specimens had been taken. Koestner (1941) and Goodnight and Koestner (1942) in studies of populations of mammals in central Illinois have emphasized the scarcity of individuals of the lemming mouse.

In the fall and winter of 1946-1947, our own investigations in central Illinois indicated that lemming mice were abundant at this time in their restricted habitat. They were caught at five previously unreported localities and were abundant at two of these places. Our most intensive investigation was undertaken along the Sangamon River, 5 miles west and 2½ miles south of Monticello, Piatt County, in the Allerton Park of the University of Illinois. Here there were several hundred, estimated at 650, acres of ungrazed, uncut blue-grass adjacent to the forest, with the latter extending down to the river's edge. Lemming mice were the dominant small mammal trapped in the Allerton Park during the fall and winter in this blue-grass habitat. Near the middle of November 1946, the number of *Synaptomys* was 35 per acre. This was more than twice the number of all the other mammals caught in the acre trapped. In February 1947, the population per acre was 20, and in March, 22 per acre (table 1) judging from our catch.

At first it was surmised that the large number of lemming mice at the fall period represented a peak in a cycle. Trapping was purposely extended through the winter in anticipation of a possible sharp decline in numbers of individuals. No such sharp decline occurred. The decline by some 40 percent from November to February was probably the result of "normal" predation without replacement by young. Females caught in February were without embryos, but on April 7 and 8 all the females caught were pregnant, as determined by the presence of a vaginal plug or embryos. Since reproduction did not extend through the winter, it might be inferred that this population of lemming mice had not reached the peak of its cycle of abundance, because information concerning other microtine rodents, such as *Microtus pennsylvanicus,* indicates that during the final year in a cycle, young are produced throughout the winter as well as the other seasons.

The three areas chosen in the Allerton Park for sampling the population and determining numbers of

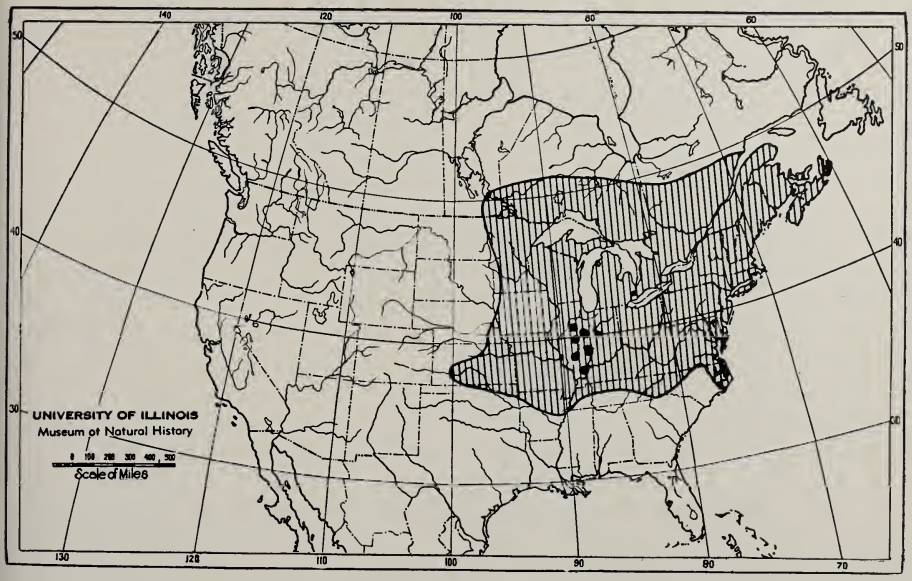

FIG. 1.—Map showing the distribution of the lemming mouse, *Synaptomys cooperi*, in North America, with localities from which specimens have been recorded in Illinois indicated by solid circles.

individuals were circular in shape. With such a shape, the perimeter is reduced and as a consequence there may be a reduction, at least theoretically, in the number of indrifting, "non-native" animals. Lemming mice are also probably more sedentary than some other kinds of small mammals and do less drifting, or shifting of home areas, when alterations in population densities occur. An acre was trapped for three days in November (10th to 12th) by D. G. Allison and R. M. Wetzel. The 130 snap-traps caught animals indicated in table 1. A half-acre, with 165 snap-traps, and five-eighths of an acre, with 97 snap-traps, were studied and trapped on February 23 and 24 and April 7 and 8, respectively. All three areas were in the grassland at the forest's edge. A few small trees were interspersed among the blue-grass. Here in the Allerton Park, lemming mice were closely associated with habitats that are predominantly, if not exclusively, of blue-grass, and are found in places where the blue-grass has not been cut or grazed for some time. The tall, uncropped blue-grass falls over providing cover and possibly protection to the surface runways, and the grass also provides a source of food. In areas in the Park where hay has been removed in the past few years, little or no sign of *Synaptomys* is evident. Wherever the lemming mice are numerous, their runways are littered with greenish fecal pellets, and in many places there is such a concentration of excreta as to form a solid mat on the floor of the runway. The presence of green fecal pellets however is not necessarily indicative of *Synaptomys* alone for the droppings

Table 1.—Numbers of Small Mammals in the Grassland Along the Sangamon River, Central Illinois, 1946-47

	Population per acre			Actual catch							Population per 650 acres		
	Nov.	Feb.	April	November (1 acre)			February (½ acre)		April (⅝ acre)		Nov.	Feb.	April
				10th	11th	12th	23rd	24th	7th	8th			
Lemming Mouse (*Synaptomys cooperi*)	35	20	22	8	13	14	7	3	9	5	22,750	13,000	14,300
Meadow Mouse (*Microtus ochrogaster*)	10	24	14	7	1	2	5	7	8	1	6,500	15,600	9,100
White-footed Mouse (*Peromyscus leucopus*)	6	6	0	2	2	2	2	1	0	0	3,900	3,900	.....
Least Shrew (*Cryptotis parva*)	0	4	0	0	0	0	1	1	0	0	.....	2,600	.....
Total	51	54	36								33,150	35,100	23,400

of the yellow-bellied meadow mouse, *Microtus ochrogaster,* occupying the same habitat, and probably the same runways, may be equally bright green. When these meadow mice are feeding solely on blue-grass, their fecal material is as green as that of *Synaptomys.*

Approximately 650 acres of grassland in the Allerton Park are suitable for occupancy by lemming mice. Superficial examination of many parts of this grassland indicates that these mice are just as abundant throughout the 650 acres as they were in the three plots that were trapped. If such an assumption is correct, one can estimate the total population of lemming mice in the Allerton Park to be 22,750 in November 1946 and 13,000 and 14,300 in February and April 1947 respectively. In spite of this concentration of lemming mice, they probably do little or no damage to the natural cover. The amount of blue-grass that they crop off has little effect upon the total cover as far as we could note. On the contrary the dry grass carried below ground adds important humus to the soil. After a heavy rain at the Allerton Park there was no free water on the surface of the ground for the excess water had been stored in underground runways. As a result of this the ground was so saturated with water that when one stepped on it the ground vibrated or quaked. The underground burrows hasten the penetration of surface water, retard run-off, and serve to retain excess water. These lemming mice are most likely beneficial, rather than detrimental, on the ungrazed, uncut grassland they occupy in at least some parts of Illinois.

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GROOMING DANCE AND ASSOCIATED ACTIVITIES OF THE HONEYBEE COLONY

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It is not within the province of this paper to describe the construction of a glass-sided observation hive for a colony of honeybees, but such a structure is highly recommended as a unit of instruction for every high school biology classroom. An established colony of bees may serve as a constant source of interest with a very low cost of installation, if the hive is constructed in a manual training or farm shop course.

Observations of honeybee activities may range all the way from entrance guarding activites to the innermost secrets of colonial life. These include the attention given the royal queen, her own activities in laying the eggs from which the entire ever-changing population of the colony develops, and the activities of the female workers in maintaining cluster temperatures, in carrying for the young, and in storing their food supplies.

Associated with the latter activities are certain well-known phenomena such as the pollen, nectar, and water dances. These dances are now considered to be a means of communication by which the incoming field bees pass on information to their fellow workers that sources of supply of pollen, nectar, and water are available.

In addition to these communication dances, other muscular exhibitions are designed principally for the creation of heat through the release of energy, either to warm the winter cluster to a highest temperature within the cluster of 75° to 85° F., or when brood rearing is in progress, to maintain an optimum temperature of near 93° F. in the brood rearing area. These heat producing activities consist of rapid breathing, vibration of the wings of individual workers for periods of several minutes, and at times a vigorous shaking of the body by individual bees within the cluster. There seems to be no doubt but that this last mentioned activity often has not been clearly differentiated from another hive activity on which we wish to report.

It has long been known by those who watch honeybees in observation hives that grooming or cleansing of the bodies of other bees is a service often rendered by one worker for a sister worker. Only recently, after sitting down to closely observe and possibly to describe this activity in detail, did we observe a more striking phenomenon, which to our knowledge has not been described previously. Much to our amazement, we soon noted that the grooming act is actually in response to a definite invitation by a worker apparently desirous of such attention.

Although a honeybee worker has many adapted structures on its legs for removing and transferring pollen and other materials to and from its various body parts, there seem to be certain areas which it cannot reach to perform its own cleansing operations. In particular, the quite

hairy region immediately caudad of or behind the points of wing attachment and extending back to the constriction between the thorax and abdomen is inaccessible to any leg structures of the individual bee, and thus the bee must depend on its sisters for grooming assistance.

Perhaps we can best describe the activities of the act if we assign some descriptive names to them. Because they are all females, possibly some beauty parlor terms would be more appropriate, but we can think of no better names than "customer" and "barber," respectively, for the "asking dancing bee" and her cooperating sister servant. As we have stated, the dance of the customer at first seems to be not unlike that of a bee that is apparently simply creating heat. In the latter case the individual worker bees may shake their bodies rapidly from side to side without attracting the attention of other workers except that sufficient room is usually allowed to avoid body contact. But the dance of a bee requiring or desiring the services of a barber seems to become more vigorous and is soon accompanied by attempts of her own to cleanse the antennae with the antennae cleaners of the front legs, of combing the hairs of the compound eyes with the pollen combs of the front legs, brushing the more posterior top and sides of the abdomen with the hind legs, but most vigorous of all, brushing the sides of the thorax with the second pair of legs.

It is at this point that the individual bee is somewhat in the predicament of the human with an itching back, particularly when the spot in question is between the points of the shoulder blades. In watching the frantic efforts of the customer bee it soon becomes apparent that she is not so constructed or provided with special leg structures for grooming portions of her own back, that is, the dorsal surface of the thorax and the anterior portion of the abdomen immediately behind the petiole, the narrowed constriction by which the abdomen is joined to the propodeum of the thorax.

The intervals of time required by the invitation dancers seem to vary considerably. In some cases a barber or grooming bee accepts the invitation or job almost immediately, in other cases there seems to be no response at all. We have been unable to determine whether a barbers' strike is in progress in such cases or whether it is just "Wednesday afternoon." In one case, we observed a worker jumping over an intervening bee, somewhat in the manner of a guard bee challenging the entrance of an incoming field bee, in this case apparently distracted by the dancing bee, but the grooming job was not accepted.

At certain times no invitation dances or grooming acts are observable, under which conditions we suspect that other activities and duties are of more immediate importance, as recently when fresh pollen was being brought in and there were numerous pollen dances in progress with the attendant excitement. On the other hand, on one occasion when there was no field activity or brood rearing, as many as a dozen grooming acts were in progress on one side of an individual frame of the observation hive.

If a near-by worker accepts the in-

vitation to grooming, she usually starts to work on the hairs near the constriction between the abdomen and thorax, spends comparatively little time on this region, and then moves forward to the region on the thorax behind the attachment of the wings where the hairs are the most concentrated, spending as long as six and one quarter minutes in one grooming act. The actual work seems to consist of combing the hairs by pulling them through the mandibles, although it is possible that portions of some hairs may be actually broken off in the process. Only the mandibles or chewing mouthparts are involved, the lapping mouthparts remaining folded beneath the head. At intervals during the grooming act, the barber backs up slightly and proceeds to clean her own mandibles, using her front legs in the process.

As soon as the grooming act is started, the customer bee ceases its dancing and thereafter gives complete cooperation by remaining motionless, even tilting the wings at a slight angle. In one instance two barbers were observed working on one customer. When one of the barbers backed up slightly to clean its mandibles, there was a slight confusion in positions and the second barber proceeded to groom the first barber. In this instance, there was no indication of any invitation having been extended. Many instances have been observed of two grooming acts in close contact with each other.

Further study may reveal more details and shed further light on the significance of these acts, but the observations to date indicate another way in which bees communicate with each other and manifest the cooperative spirit for which they have long been noted and praised for human exemplification.

MAJOR FLUCTUATIONS OF SOME ILLINOIS MAMMAL POPULATIONS

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The following notes constitute a partial history of fluctuations of some mammal populations in Illinois. They are often not continuous, nor made on equal bases, but in most cases constitute our only records. They are set down here in the belief that, when others are added in the future, the entire history will aid researchers in discovering specific causes of the fluctuations so as to predict and account for future changes.

Norway Rat

Beginning in the year 1934, the writer, while traveling widely in Illinois, recorded the numbers of certain animals seen crushed on the highway. During the course of the years up to 1939, he saw only one, two, or three rats crushed annually, usually only in cities.

In 1937 Starrett (1938) recorded only one rat per 1,255 miles in 7,529 miles of travel (3,229 during summer and early fall) within 80 miles of Peoria.

During 1939, however, the number seen crushed on highways increased suddenly. Two or three were seen during the course of most 200-mile trips. An average of one rat per 26 miles was seen during the course of the summer and fall over most of the state (fig. 1). The next year, 1940, was similar. An average of one rat per 34 miles was observed in 1,943 miles of travel. In 1941 the number seen fell to that of preceding normal years. Only two were seen in about 2,000 miles. The peak of greatest abundance had passed.

No observations were made during 1943, 1944, or 1945, but all farm advisers of 10 widely scattered county farm bureaus which were contacted state that rats were not unusually numerous during those years, though increasing somewhat in a few localities.

The writer's observations were continued early in 1946, records being made on the basis of mileage traveled. This was another year of large rat populations, the observed highway kills being more comparable with those of 1939 and 1940 than with any intermediate years. While

Technical and Common Names of Mammals Discussed

Gray fox	*Urocyon cinereoargenteus* (Schr.)
Groundhog	*Marmota monax* (Linn.)
Norway rat	*Rattus norvegicus* (Erx.)
Opossum	*Didelphis virginiana* Kerr.
Pennsylvania meadowmouse	*Microtus pennsylvanicus* (Ord.)
Prairie meadowmouse	*Microtus ochrogaster* (Wagn.)
Raccoon	*Procyon lotor* (Linn.)
Red fox	*Vulpes fulva* (Desm.)
Skunk	*Mephitis mephitis* (Schr.)

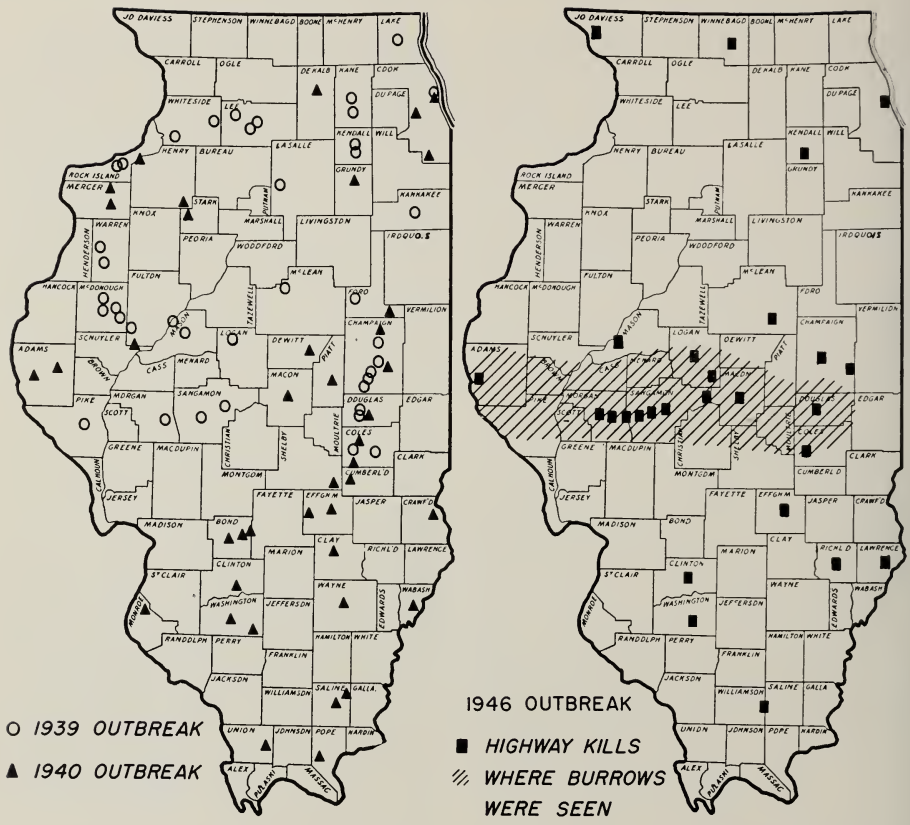

Fig. 1.—Localities where Norway rats or their signs were observed during two outbreaks, one of 1939 and 1940 and the other beginning in 1946. Circles, triangles and rectangles indicate localities where rats were seen dead on highways and streets. The hatched area indicates a zone where the writer observed large numbers of rat burrows alongside or in corn fields during the winter of 1946-47. Without doubt, a more intensive survey would have revealed burrows in a marginal area extending north, south and east of the area, though in much smaller numbers. No observations were made on distribution of burrows during the winters of 1939 and 1940.

traveling 5,726 miles from May 1946 to March 1, 1947, the writer observed 52 rats or one to approximately 110 miles. Because the number of rats observed crushed might depend much upon volume of traffic, comparative notes were made on cats whose number served as a basis. Ninety-eight were found killed, making about one rat to every two cats. During normal rat years, the number of cats observed crushed is a hundred or more in excess of rats.

Silver (1942) wrote "Their number varies locally from year to year though there is now no known cycle of rat abundance." There are few records of other outbreaks in Illinois.

Zinsser (1935) wrote "Dr. Lantz tells us that in 1903, hordes of rats migrated over several counties in

western Illinois, suddenly appearing when for several years no abnormal numbers had been seen." He adds that heavy damage was caused by rats in the entire surrounding country of farms and villages in the ensuing winter and summer.

Groundhog

The groundhog appears to be on the increase in many parts of Illinois, but the increase is not general. At Lima, Adams County, an orchardist stated that these animals had become very abundant about 1940 but that about 12 years ago, which would be about 1935, "he hardly knew what they were."

Much the same story was given by J. E. Watt, farm adviser at Fulton County, who stated that 25 years ago (1922) when he came to Fulton county, these animals were extremely scarce. Now they are a common problem.

The late W. P. Flint of the Natural History Survey stated that when he came to Illinois in 1918 groundhogs were practically unknown around Springfield and East St. Louis.

In Massac County they have become more numerous in the last 3 years and are now very numerous according to Leonard Devers, Department of Conservation Inspector.

The farm adviser in Carroll County states that groundhogs have become more numerous there during the last three years but that they are still relatively uncommon. Twelve to 15 years ago, he said, they were extremely numerous, then suddenly declined[1] in abundance.

The farm adviser of Whiteside County states that these animals are now relatively uncommon there. Neither are they especially numerous in Edgar County according to the county farm adviser.

Coon

An attempt to keep running index figures which might measure trends in furbearer populations was begun in 1934, using trapper's reports.[2] Although the total number of coons caught is so dependent on fluctuations in price, weather, and nature of persons reporting that it reveals but little, the percentage of trappers and furhunters who caught them, i.e. effective coon trappers, kept pace in considerable measure with known changes in coon populations. So did the average number of coons caught per effective trapper. The percentages and averages for each county were weighed according to county size and recorded by the writer (1943). They need not be repeated in detail here. For the 1934-35 season, the percentage-index was 24 and rose rather steadily to 37 during the 1941-42 season. Preliminary examination of 1945-46 data indicates that it continued to rise. A straight unweighted percentage shows the same general trend.

The average-index figure started at 2.6 and rose rather steadily to 3.0. This is, however, not necessarily regarded as accurate as the percentage-index figure.

Coon hunters and trappers, and game investigators are generally agreed that throughout Illinois coons are as common or more common this

[1] G. C. Oderkirk, federal predator and rodent control agent, says that an intensive campaign was conducted to reduce their number.

[2] These reports were kindly made available by the Honorable Livingston E. Osborne, Director of the Illinois State Department of Conservation, and preceding directors.

(1946-47) season as they have ever seen them. In Jo Daviess County, northwestern Illinois, Leroy Felderman, game investigator, stated that coon numbers increased markedly in the last three years and that an increase was noticeable there as long as 8 years ago. They are now seen in places where they were absent before.

A hunter in Alexander County, southwestern Illinois, stated that coons were scarce during 1917, of moderate numbers from 1930 to 1936, then became increasingly abundant, and are now more common than ever before within his memory. Their tracks are so numerous in cornfields that it looks as if a herd of hogs had been in them.

John C. Knight, Jr., reported in 1947 that his father had observed the territory around Yorkville, northeastern Illinois, for many years and stated that coon populations had never been as high as during this year. Coons there appeared to increase in numbers about four years ago.

Brown and Yeager (1943) state that many experienced furtakers were emphatic in their opinions that up to 1939 a decrease in coon populations had been steady and rapid during the preceding 5 to 10 years. During 1941 and 1942 when their report was being prepared for publication, they recorded that they had numerous and apparently reliable reports of increases in coon numbers, noticeable particularly in 1941 and 1942.

A hunter in Adams County, on the far western edge of Illinois, states that coons also became numerous there four years ago. Lyman Bunting, president of the coon-hunters association in Edwards County on the southeastern quarter of Illinois, stated that in 1942 or 1943 an abrupt natural increase became very apparent and that coons now exceed any previous number that he has known. Other similar statements are at hand from Rock Island, Will, and Mason counties. They generally set the beginning of noticeable increase for about 10 years ago and the beginning of a decided increase three or four years ago. This fits the trend indicated by the percentage-index and average-index described above. There is general agreement among the various opinions and indices that the rise began 10 to 12 years ago and has continued upward.

This increase cannot be attributed, for any practical purpose, to artificial coon propagation. It is widespread in eastern United States.

Possum

It is reasonable to suppose that if possum populations vary consistently some of the trend will be reflected in the percentage of trappers and fur-hunters taking them, as possums are caught in much the same time, place, and manner as coons are caught. Percentage-index figures recorded by the writer (1943) for the same years as for coons show, not a gradual rise from 1934 as for the latter animals, but a high of 74 which fell to a low of 60 for the 1937-38 season, then rose gradually to 68 during the 1939-40 season and dropped gradually to 61 during the 1941-42 season. The average-index figures showed the same general trend during those years. Considering the strong steady rise of the figures for coons

as a base for comparison, the possum figures undulated clearly with reference to them.

The general impression of the writer is that possums are now again numerous. During previous years of travel it was unusual to see a possum crushed on the highway more than once in some 1000 miles of travel. During the summer of 1946 and the following winter until March 1, 27 possums were observed for each 3.6 cats. Starrett (1938) recorded only two in 7529 miles of travel within 80 miles of Peoria during 1937.

A coon hunter in Edwards County and another in Mason County stated that possums are more numerous than usual there. They began to increase in numbers about 1942 or 1943. A game investigator in Mason County stated that possum populations were common for a while, then became uncommon, and are now on the upswing. He did not remember the years of abundance and scarcity. A trapper in Will County stated that their numbers were low three or four years ago but that they are common now.

The game investigator in Jo Daviess County, Leroy Felderman, stated that a marked increase in possum populations became apparent three years ago and that they are common now. In Massac County possums are now common, according to a coon hunter there, their numbers having increased since a low three or four years ago.

Brown and Yeager (1943) wrote that, in general, fur-takers who were interviewed reported a steady increase in possum numbers from 1936 to 1939 when populations seemed to level off or decrease. This is paralleled exactly by index figures cited above.

At this date we have no parallel index figures worked out from trappers data since 1942. The "lows" spoken of by the above observers appear to link up with the low of 61 for the 1941-42 data from trappers reports. All indicate a fairly regular undulation of population levels for the years in question.

Red Fox

According to a correspondent, John C. Knight, his father, keenly interested in fox hunting by tracking, found only few fox tracks after a long search in Kendall County seven or eight years ago. Now he finds such tracks without much search and has trouble following them because of the numerous other tracks.

According to a fox-runner, red fox numbers were lowest about 10 years ago in Massac County and are more common now than at any time within his memory. They are so common that, whereas he had to drive as much as 10 miles during the low population period to give his dogs a good trail, a half mile is now sufficient, and he can frequently start the dogs at his door. The numbers are so great that several dogs may start foxes, thus splitting the dog pack and making for a poor chase.

Leroy Felderman stated that the numbers of red fox were lowest in Jo Daviess County about 15 years ago and have now reached their all time high within his memory.

In Rock Island County, a coon hunter reported that they were lowest in number about 10 years ago

and have reached an all time high in his 35 years of experience.

In Adams and Mason counties, farmers stated that foxes have continued to increase in number for quite a few years and are now very common.

Percentage-index figures derived from trapper's reports for red and gray foxes combined show a general increase from 14 for the 1934-35 season to 16 for the 1941-42 season, last for which we calculated returns. There were, in this general upward trend, some fluctuations which may or may not indicate a corresponding minor change in actual fox populations. One of these was a drop back to 14 for the 1938-39 season and the other was a sudden rise to 18 for the 1940-41 season. The general trend, however, was upward and began 12 years ago.

According to Brown and Yeager (1943), of a total of 165 expressions of opinion tabulated by them up to 1939, by far the greater number (about 70 percent) believed that foxes had recently (1938 and 1939) increased in numbers. The remainder of opinion was equally divided between no change and decrease.

Index figures for both species of foxes by the writer (1943) agree with these opinions.

This increase is not by any means confined to Illinois but is widespread in eastern United States.

Gray Fox

Statements by trappers and fox-runners indicate that gray fox numbers generally fluctuate in about the same way red foxes do. Separation of the figures for grays is difficult but would be desirable. Any large changes in their numbers are commonly reflected in their appearance and disappearance in areas which are generally not too suitable for them. During the present (1946-47) season they are more frequently reported from well out in the prairie sections of Illinois.

Brown and Yeager (1943) were fortunately able to obtain separate data on gray foxes. These indicate strongly that this species was on the increase preceding and during the 1938-39 and 1939-40 trapping seasons. Seventy-five percent of 80 trappers interviewed believed that gray foxes had increased. Only 14 percent believed that they had decreased in numbers and 11 percent that the numbers had not changed essentially.

John C. Knight, Jr., reports that his father had up to 1940 gotten only two gray foxes in many years of hunting and trapping in Kendall County, but since then has gotten ten. The grays are now present in most of the wooded stream valleys around Yorkville, Kendall County, according to Knight.

Leroy Felderman stated that grays were now present in prairie sections in northwestern counties in Illinois where they were previously limited to the rougher more wooded sections. Their numbers had increased along with those of red foxes.

A fox runner in Massac County stated that both gray fox numbers and red fox numbers had increased beginning about ten years ago.

Skunk

Highway kills as described for rats and possums indicate relatively large numbers of skunks during the 1946-47 season. Seven were observed in 5,726 miles traveled from

May 1946 to March 1, 1947. This equals one skunk per 818 miles and one per 14 cats. The usual observed kill is one or two in several thousand miles and several hundred cats.

Lyman Bunting of Edwards County stated that 5 to 7 years ago skunks were dying of disease there but their numbers have since increased and they may be seen frequently.

Trapper's data converted for skunks as for coons, possums, etc. by the writer (1943) do not, as for some of the other furbearers, have sufficient parallel data for comparison. They indicate a general decline from 1934 to 1942. For the two years in particular question, they agree with trappers opinions described by Brown and Yeager (1943). They report a 33 percent decrease in the total number of skunks caught during the 1939-40 season as compared with the previous season and believe that this reflects a substantial decrease in actual populations. Their tabulation of opinions by fur takers regarding changes of population shows that essentially equal numbers believed that an increase or decrease had taken place, and that a small though substantial number thought that the population had remained about the same. These data indicate a general downward decline until about 1942, then a gradual rise.

Prairie Meadowmouse

Hamilton (1937) found "All available evidence points to a 4-year cycle" of Pennsylvania meadowmouse abundance in northeastern United States. He stated that past periods of great mouse abundance in New York were the winters of 1919-20, 1923-24, 1927-28, 1931-32 and 1935-36. He added that peaks of future cycles might accordingly be expected in the winters of 1939-40 and 1943-44.

The species of which he wrote only occurs in northern Illinois. It remains to be seen whether or not the cycles described by Hamilton are shared by the prairie meadowmouse whose distribution pattern is more extensive in Illinois.

This latter species did become extremely numerous over much of Illinois by the winter of 1939-40 but, according to R. E. Yeatter, a fellow worker, became abundant again in three years, not four. It then reached another peak of abundance at the end of three more years by the winter of 1945-46.

Prairie meadowmice were particularly abundant in northern and western Illinois during 1946 according to an annual report by Oderkirk (1947) unpublished.

They were more than usually abundant at Champaign during the late winter of 1945 and continued so until at least late fall of 1946. Farmers or farm advisers, again reported them particularly abundant in Fulton County during 1947; in Adams County during 1946 and 1947; in Monroe County during 1946 and 1947; and Sangamon County during 1946. They were also troublesome in one orchard in Lake County during 1946 and early 1947.

Farm advisers in Edwards, Henderson, Massac, Pulaski, and Alexander counties do not find them especially numerous. This is partly because in these counties, not being red-clover or alfalfa producing counties, farmers do not have trouble

with them and partly because the yellow soil areas do not, even during mouse years, have a large population. Meadowmouse numbers in Jo-Daviess County appear to be nontroublesome although the mice may be more numerous than usual where suitable conditions exist for them.

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PARASITES OF THE HYLIDAE (AMPHIBIA-HYLINAE). VI

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In this sixth section of the catalog of the parasites of the Hylinae, the following hosts and parasites are included:

1. HYLA FABER (Brazil)—*Cosmocerca brasiliensis, Foleyella convoluta, Oswaldocruzia subauricularis, Oxyascaris similis, Physaloptera* sp? of Travassos, 1928, *Raillietnema simples,* and *Spironoura nitida* (Nematoda); larval *Lueheia luehei* (Acanthocephala); *Cepedea plata, Nyctotherus faberi, N. fulvus, N. mogyanus, N. ruber, Opalina elongata, O. faber, O. longula,* and *O.* sp? of Carini, 1935 (Protozoa); and *Schmardaella lutzii* (Annelida).

2. H. FEMORALIS (U.S.A.)—*Oxysomatium americana* (Nematoda); and *Opalina obtrigonoidea,* and *O.* (?) *triangularis* (Protozoa).

3. H. FREYCINETI (Australia)—*Dolichosaccus diamesus,* and *Pleurogenes freycineti* (Trematoda); and *Nematotaenia* sp? of Johnston, 1916 (Cestoda).

4. H. FUSCOVARIA (S. Amer.)—*Cepedea ciliata, Isospora cruzi, Nyctotherus incertus,* and *N. ruber* (Protozoa).

5. H. GOUGHI (S. Amer.)—*Schmardaella* sp? of Lutz 1928 (Annelida).

6. H. GRACILENTA (Australia)—*Parathelandros mastigurus* (Nematoda); and *Mesocoelium microon* (Trematoda).

7. H. GRATIOSA (U.S.A.)—*Oxysomatium americana,* and *Spironoura catesbianae* (Nematoda).

8. H. INFRAFRENATA = *H. dolichopsis* (Papua)—*Protoopalina papuensis* (Protozoa).

9. H. JERVISIENSIS (Australia)—*Aplectana flindersi, Hedruris hylae,* and *Raillietnema kartanum* (Nematoda).

10. H. LANGSDORFII (Brazil)—*Aplectana* sp? of Travassos, 1925 (Nematoda); and *Nyctotherus faberi,* and *N. fulvus* (Protozoa).

11. H. LESUERII (Australia)—*Parapolystoma bulliense* (Trematoda); and *Entamoeba morula, E. ranarum, Trypanosoma* sp? of Johnston, 1916 and *T.* sp? of Laveran and Mesnil, 1912 (Protozoa).

12. H. LEUCOPHYLLATA (Brazil)—*Cepedea mogyana,* and *Nyctotherus ondinae* (Protozoa).

13. H. LUTEUS (Brazil)—*Aplectana acuminata and Cosmocerca commutata* (Nematoda).

14. H. MESOPHAEA (Brazil)—*Aplectana* sp? of Travassos, 1925, *Oswaldocruzia subauricularis,* and *Thelandros oswaldocruzi* (Nematoda); and larval *Centrorhynchus tumidulus* (Acanthocephala).

15. H. MICROPS (Brazil)—*Aplectana* sp? of Travassos, 1925 (Nematoda); and *Nyctotherus vulgaris* (Protozoa).

* Contributions from the Biological Laboratories of Knox College, No. 115.

16. H. MINUTA (Brazil)—*Cepedea rubra* (Protozoa).

17. H. MISERA (S. Amer.)—*Schmardaella lutzii* (Annelida).

18. H. NANA (S. Amer.)—*Zelleriella* sp? of Chen & Stabler, 1936 (Protozoa).

19. H. NASICA (Paraguay)—*Cepedea dimidiata paraguayensis*, and *Isospora cruzi* (Protozoa).

20. H. NASUTA (Australia)—*Trypanosoma* spp? of Bancroft, 1890, Johnston, 1916, and Laveran & Mesnil, 1912 (Protozoa).

21. H. NEBULOSA (S. Amer.)—*Cepedea rugosa, Myxidium lindoyense, Nyctotherus cinctus, N. elegans, N. ruber, Opalina nebulosa*, and *O.* sp? of Carini, 1935 (Protozoa).

22. H. PARDALIS (Brazil)—larval *Lueheia luehei* (Acanthocephala).

23. H. PERONII (Australia)—*Rhabdias hylae* (Nematoda); and *Entamoeba morula* (Protozoa).

24. H. PHRYNODERMA (Brazil)—*Aplectana* sp? of Travassos, et al., 1939 (Nematoda).

25. H. PHYLLOCHROA (Australia)—*Parapolystoma bulliense* (Trematoda).

26. H. POLITAENIA (S. Amer.)—*Nyctotherus ondinae, N. ruber*, and *N.* sp? of Carini, 1939 (Protozoa).

27. H. RADDIANA = *H. pulchella* (S. Amer.)—*Acanthocephalus lutzii* (Acanthocephala); and *Cepedea brumpti, Mastigamoeba hylae, Myxidium immersum, Nyctotherus* (?) *cordiformis, N. fragilis, Opalina raddiana, O.* sp? of Carini 1935, *Trypanosoma rotatorium, T. rotatorium major*, and *Zelleriella hylaxena* (Protozoa).

28. H. REGILLA (U.S.A.)—larval *Paralechriorchis syntomentera* (Trematoda) in tadpoles; larval *Centrorhynchus californicus* (Acanthocephala); and *Nyctotherus* (?) *cordiformis hylae* (= *N. hylae* of Rosenberg and (?) of Surowiak), *Opalina oregonensis, O. virguloidea*, and *Trichomonas augusta* (Protozoa).

29. H. RUBRA (S. Amer.)—larval *Strigea vaginata* (Trematoda); *Cepedea rubra, Isospora cruzi, Myxidium lindoyense, Nyctotherus mogyanus, N. tieteanus, Opalina elongata, O.* spp? of Carini, 1935-1937, *Trypanosoma borrelli, T. rotatorium*, and *T.* sp? of Laveran & Mesnil, 1912 (Protozoa); *Dermosporidium hylarum* (Phycomycetes); *Schmardaella lutzii* (Annelida); and *Eutrombicula yorkei*, and *Hannemania newsteadi* (Acarina).

30. H. SEPTENTRIONALIS (Cuba)—*Eustrongylides* sp? of Walton, 1940, *Oswaldocruzia lenteixeirai*, and *Pharyngodon bassi* (Nematoda); *Balantidium* sp? and *Nyctotherus* sp? of Metcalf, 1923, *Opalina septentrionalis*, and *Zelleriella* sp? of Metcalf, 1923 (Protozoa); *Schmardaella lutzii* (Annelida); and *Borrelia cubensis* (Bacteria).

31. H. SQUIRELLA (U.S.A.)—*Cosmocercoides dukae*, and *Rhabdias ranae* (Nematoda); larval and adult *Polystoma nearcticum* (Trematoda); *Cylindrotaenia americana* (Cestoda); and larval *Acariscus mansoni* (Acarina).

32. H. TASMANIENSIS (Australia)—*Nyctotherus* (?) *cordiformis* (Protozoa).

33. H. (?) TSCHUDII (Brazil)—*Aplectana acuminata*, and *Cosmocerca commutata* (Nematoda).

34. H. VENULOSA (S. Amer.)—*Balantidium* sp? of Metcalf, 1923, *Nyctotherus gamarrai, Trypanosoma* spp? of Laveran & Mesnil, and of Plimmer, 1912, and *Zelleriella venezuelae* (Protozoa); and *Schmardaella lutzii* (Annelida).

35. H. VERSICOLOR (U.S.A.)—larval *Apharyngostrigea pipientis, Cercaria amherstensis* (in tadpoles), *C. holthauseni* (in tadpoles), and larval *Polystoma nearcticum* (Trematoda); and *Balantidium* sp? of Metcalf, 1923, *Nyctotherus* (?) *cordiformis, Opalina hylaxena, O. h. georgiana, O. h. mexicana, O. h. orbiculata, O. h. parvinucleata, Scyphidia* sp? of Wenrich, 1924 (on tadpoles), *Trichomonas augusta, Trypanosoma* (?) *rotatorium,* and *T.* sp? of Negrelli, 1945 (Protozoa).

36. H. VERSICOLOR CHRYSOSCELIS (N. Amer.)—*Cepedea* sp? and *Opalina* sp? of Metcalf, 1923 (Protozoa).

37. H. sp? (Australia)—*Dolichosaccus* spp? of Johnston, 1912, and *Pleurogenes* sp? of Roberts, 1936 (Trematoda).

38. H. sp? (Brazil)—*Ascaris foecunda* (Nematoda); and larval *Clinostomum heluans,* and larval *Echinostoma nephrocystis* (Trematoda).

39. H. sp? (Europe)—*Oswaldocruzia* sp? of Dikmans, 1932 (Nematoda).

40. H. sp? (Japan)—*Capillaria filiformis* (Nematoda).

41. H. sp? (N. Amer.)—*Triatoma sanguisuga ambigua* (Hemiptera).

A survey of the records of this and the earlier studies indicates that the "Tree Frogs" of the family *Hylidae* are widely distributed and heavily parasitized. 71 identified and 5 unidentified host species have been examined as follows: ACRIS (3 spp.) from the U.S.A., AGALYCHNIS (2 spp.) from Central America, HYLA (63 spp.) from all of the continents except Africa (1 sp. from Asia Minor, 14 spp. from Australia, 4 spp. from Central America, 1 sp. from Cuba, 3 spp. from Europe, 2 spp. from Japan, 2 spp. from Mexico, 1 sp. from Papua, 23 spp. from S. America (20 from Brazil), and 12 spp. from the U.S.A. and Canada), PHYLLOMEDUSA (2 spp.) from Central and Northern S. America, and PSEUDACRIS (6 spp.) from the U.S.A. The *Hylidae* apparently originally evolved in the South American rain-forest area (about 100 spp. are reported) and spread to North America (about 50 spp. are known). The presence of over 40 spp. of hylids in Australia necessitates consideration of the possibility of an independent center of origin from archaic bufonids of the region. This seems doubtful inasmuch as the parasites of the hylids do not seem to have arisen from those of the bufonids as is the case in South America, but show direct relationship to some of the more highly modified types of the less primitive New World host species. Migration from a Western Hemisphere source seems therefore much more plausible than independent origin although it requires the postulation of southern land bridges between Australia and South America, either by direct trans-Pacific crossing or via the Antarctic Continent. Hylids appeared in Australia too late to have entered by way of the Malayan land bridge. Arldt and other paleogeographers have advanced evidences of former land bridges in Late Cretaceous or Early Tertiary times, extending: (a) from Peru westward through the chain of islands of the modern South Pacific to Australia and New Guinea; and (b) from Chile southeastward through present-day islands to Antarctica and thence westward and northward to Australia

and New Guinea. Such data are not conclusive in the opinion of many other paleogeographers. The Australian hylids are more nearly related to South American species than they are to the North American or European forms and thus a northern pathway from South America to Australia seems to be ruled out even though such a migration should have occurred early enough to have used the Malayan bridge which, however, is usually regarded as having disappeared before the appearance of the hylids. It is difficult to believe that all connecting forms should have entirely been wiped out and replaced by the more modern species which are traceable directly back to a Neotropical ancestry. The present 5 or 6 Eurasiatic hylids (mainly varieties of *Hyla arborea*) are definitely late Tertiary derivatives of North American species and entered their area by way of the Alaska-Siberia preglacial land bridge. These North American forms antedate the Australian forms but could not have been ancestral to them.

Study of the parasites bears out the same general conclusion of the Late Cretaceous and Early Tertiary evolution of the Hylidae inasmuch as few of the nematode, the trematode, or the protozoan species found are truly primitive forms. Metcalf has presented this analysis in detail for the opalinid protozoans, and a survey of the other protozoa and of the metazoa involved substantiate his interpretations.

The two species of *Acris* from North America show the presence of 6 species of nematodes, 3 species of cestodes, and 9 species of protozoans. The two species of *Agalychnis* from Central America show 2 species of Opalinids. The two species of *Phyllomedusa* from Central America and Northern South America are hosts to 1 species of nematode and to 2 species of protozoans. The six species of *Pseudacris* from North America are parasitized by 9 species of nematodes, 5 species of trematodes (several of them only in larval form), 1 species of cestode, 1 species of a larval acanthocephalan, and 12 species of protozoans. The four identified and two unindentified species of *Hyla* from Eurasia (including Japan) are reported as hosts of 8 adult and 1 larval species of nematodes, 10 adult and 5 larval species of trematodes, 2 adult and 2 larval species of cestodes, 1 adult and 1 larval species of acanthocephalans, 18 identified and 4 unidentified species of protozoans, 1 species of bacterium, and 1 species of a fly maggot. The adults of the larval species are normally found in birds or reptiles, the amphibia serving only as intermediate, or in some cases, as accidental hosts. 14 species of *Hyla* from Australia are parasitized by 8 adult and 2 larval species of nematodes, 18 species (2 not identified) of trematodes, 5 species of adult (3 identified only as to genus) and 1 species of larval cestodes, 1 species of larval acanthocephalans, 18 species of protozoans, and 1 species of a larval dipteran. The one *Hyla* species from Papua was parasitized by a single form of the protozoans. The 4 species of *Hyla* from Central America and the northern border of adjacent South America are hosts to 1 species of trematode, to 9 species of protozoans, and to 1 species of annelid.

Specimens of 2 species of hylids from Mexico and adjacent Central America yielded 1 species of nematode, 1 species of trematode, and 5 species of protozoans. The one hylid species examined from Cuba was host to 2 adult and 1 larval species of the nematodes, 4 species of protozoans, 1 of an annelid, and 1 of a bacterium. 12 species of nematodes (including 3 larval species), 12 species of trematodes (including 4 species of larval forms whose adults are found in birds or reptiles and 2 species of metacercariae whose adults are as yet unknown), 1 adult and 2 larval species of cestodes, 2 species of larval acanthocephalans, 25 species of protozoans, 2 species of larval mites, and 1 species of an hemipteran, have been reported from the genus *Hyla* taken in the United States and in Canada. The 27 South American species of *Hyla* (20 species from Brazil) are hosts to 12 adult and 2 larval species of nematodes, 4 species of larval trematodes, 1 adult and 2 larval species of acanthocephalans, 40 identified species of protozoans, 1 species of an annelid, 1 species of a phycomycete, and 2 species of larval mites.

Among the Nematoda, 22 genera and 40 identified species are present. Eight larval forms, identified only as to their genera, are also reported. *Aplectana* with 4 species, *Cosmocerca* with 3, *Oswaldocruzia* with 7, *Rhabdias* with 3, and *Spironoura* with 4, are the genera most frequently encountered. *Rhabdias* is the most widely distributed genus, species being reported from 11 different hosts, collected from all of the continents where hylids are found. *Cosmocercoides dukae* is the one species occurring in the greatest number of hosts, six, although thus far reported only from the North American area. 14 species of nematodes are reported from the U.S.A., 13 from South America, 10 from Australia, 6 from Europe, 3 each from Japan and from Cuba, and 1 from Mexico. *Aplectana acuminata* and *Cosmocerca commutata* are the only species definitely identified as being present on two continents, Europe and South America.

NEMATODE PARASITES[1]

**Agamascaris enopla* U.S.A. (1)
**Agamascaris odontocephala* U.S.A. (3)
**Agamonema* sp? Australia (1)
Aplectana acuminata E., S. Amer. (1 each)
Aplectana flindersi Australia (1)
Aplectana hamatospicula Mexico (1)
Aplectana spp? S. Amer. (5)
Ascaris foecunda S. Amer. (1)
Capillaria filiformis Japan (1)
Cosmocerca brasiliensis S. Amer. (1)
Cosmocerca commutata E., S. Amer. (1 each)
Cosmocerca japonica Japan (1)
Cosmocercella haberi U.S.A. (1)
Cosmocercoides dukae U.S.A. (6)
**Eustrongylides* sp? Cuba (1)
Foleyella convoluta S. Amer. (1)
Hedruris hylae Australia (1)
Oswaldocruzia filiformis E. (1)
Oswaldocruzia leidyi U.S.A. (3)
Oswaldocruzia lenteixeirai Cuba (1)
Oswaldocruzia limnodynastes Australia (1)
Oswaldocruzia minuta U.S.A. (1)
Oswaldocruzia pipiens U.S.A. (3)
Oswaldocruzia subauricularis S. Amer. (3)
Oswaldocruzia sp? E. (1)
Oswaldocruzia sp? S. Amer. (1)
Oxyascaris similis S. Amer. (1)
Oxysomatium americana U.S.A. (3)
Oxysomatium brevicaudatum E. (1)
Oxyuris tba E. (1)
Parathelandros mastigurus Australia (2)
Pharyngodon bassi Cuba (1)
**Pharyngodon confusa* Australia (1)
**Pharyngodon* sp? S. Amer. (1)
**Pharyngodon* spp? U.S.A. (3)
Raillietnema kartanum Australia (1)

[1] *Denotes larval forms. Number in parentheses indicates the number of host species from which the parasite has been reported. E. refers to Europe.

Raillietnema simples S. Amer. (1)
Rhabdias bufonis Japan (1)
Rhabdias hylae Australia (3)
Rhabdias ranae U.S.A. (4)
Rhabdias sp? Australia (1)
Rhabdias sp? U.S.A. (2)
Spironoura catesbianae U.S.A. (2)
Spironoura hylae U.S.A. (1)
Spironoura nitida S. Amer. (1)
Spironoura simpsoni Australia (1)
Thelandros oswaldocruzi S. Amer. (1)
Thubunaia liolopisma U.S.A. (1)
(normally in lizards)

Thirty-one genera (43 identified and 6 unidentified species) of trematodes have been reported from members of the *Hylidae*. *Mesocoelium* with 4 species, *Pleurogenes* with 5, and *Polystoma* with 4 are the best represented genera. *Brachycoelium salamandrae, Megalodiscus temperatus, Opisthodiscus subclavatus,* and *Polystoma nearcticum* have each been reported from 3 host species. *O. subclavatus* is the only species to be reported from two continents (Australia and Europe). The 2 species of "Cercaria" have been reported from tadpoles, but their life-histories are asyet undetermined and their adult forms not as yet ascertained. 12 additional larval species are recorded—their adult forms being found in fish, reptiles, and birds —with the amphibians merely serving as intermediate hosts. 18 species of parasites are reported from Australia, 15 from Europe, 12 from the U.S.A., 4 from South America, and 1 from Central America and Mexico.

Trematode Parasites

Asymphlyodora tincae E. (1)
**Apatemon gracilis* S. Amer. (1)
**Apharyngostrigea pipientis* U.S.A. (1)
Brachycoelium salamandrae U.S.A. (3)
Brachysaccus anartius Australia (1)
Brachysaccus symmetricus Australia (1)
**Cercaria amherstensis* (tadpoles) U.S.A. (1)
**Cercaria holthauseni* (tadpoles) U.S.A. (1)
**Clinostomum heluans* S. Amer. (1)
**Dasymetra villicaeca* U.S.A. (2)
Distomum sp? U.S.A. (1)
Distomum sp? Australia (1)
**Dolichoenterum lemirandi* E. (1)
Dolichosaccus diamesus Australia (1)
Dolichosaccus ischyrus Australia (1)
Dolichosaccus tryphesus Australia (1)
Dolichosaccus spp? Australia (2)
**Echinoparyphium recurvatum* E. (1)
**Echinostoma nephrocystis* S. Amer. (1)
Glypthelmins quieta U.S.A. (2)
Glypthelmins sp? U.S.A. (1)
Gorgodera australiensis Australia (1)
Gorgodera cygnoides E. (1)
Haematoloechus australis Australia (1)
Haplometra cylindracea E. (1)
Lecithochirium rufoviride E. (1)
Lecithopyge ranae E. (1)
Megalodiscus temperatus U.S.A. (3)
Mesocoelium megaloon Australia (1)
Mesocoelium mesembrinum Australia (2)
Mesocoelium microon Australia (2)
Mesocoelium oligoon Australia (1)
**Neorenifer aniarum* U.S.A. (2)
Opisthodiscus subclavatus E., Australia (3)
**Paralechriorchis syntomentera* U.S.A. (1)
Parapolystoma bulliense Australia (2)
Pleurogenes claviger E. (1)
Pleurogenes freycineti Australia (1)
Pleurogenes medians E. (1)
Pleurogenes solus Australia (1)
Pleurogenes sp? Australia (1)
Polystoma gallieni E. (1)
Polystoma integerrimum E. (2)
Polystoma naevius Mex., Cent. Amer. (1)
Polystoma nearcticum U.S.A. (3)
**Prosorhynchus aculeatus* E. (1, exper.)
**Sphaerostoma bramae* E. (1)
**Strigea vaginata* S. Amer. (2)
**Szidatia joyeuxi* E. (1)

Among the Cestodes, 9 genera—with 7 identified and 5 unindentified species (5 of the 12 are larval forms) —are parasitic in the *Hylidae*. At least 1 species of a proteocephalid is present in encysted form, 2 species of *Sparganum* larvae and 1 species of a larval "*Taenia*" are reported. *Ophiotaenia* is represented by 2 species, one each from Australia and from the United States. *Nematotaenia dispar* has been recovered

from 2 host species, 1 each from Europe and from the United States. Probably this same species has been recovered from 2 host species in Australia, but the identification was not completely established. *Cylindrotaenia americana* has been reported from 3 different U.S.A. hosts. Australia reports 5 species, the U. S. A. 5 species, Europe 3 species and Japan 1 species of tapeworms. South America has no recorded findings of cestodes as parasites of the hylids.

CESTODE PARASITES

Baerietta japonica Japan (1)
Cylindrotaenia americana U.S.A. (3)
**Diphyllobothrium erinacei* E. (1)
Nematotaenia dispar E., U.S.A. (1 each)
N. spp? Australia (2)
Ophiotaenia hylae Australia (1)
Ophiotaenia magna U.S.A. (1)
Ophiotaenia sp? Australia (1)
*Proteocephalid cysts U.S.A. (1)
**Sparganum* spp? Australia (2)
**Taenia* sp? U.S.A. (1)
**Tetrathyridium* sp? E. (1)
Triplotaenia mirabilis Australia (1)

Acanthocephala (2 adult and 7 larval species) are represented by 3 genera. Hosts from Australia, Europe, North America, and South America, have been found to be parasitized.

ACANTHOCEPHALAN PARASITES

**Acanthocephala hylae* Australia (2)
Acanthocephala lutzii S. Amer. (1)
Acanthocephala ranae E. (1)
**Centrorhynchus aluconis* E. (1)
**Centrorhynchus californicus* U.S.A. (1)
**Centrorhynchus tumidulus* S. Amer. (1)
**Centrorhynchus* spp? U.S.A. (2)
**Lueheia luehei* S. Amer. (2)

The Protozoa of the *Hylidae* have been carefully studied by Carini and by Metcalf, and are perhaps better known than are any of the other groups of parasites. 21 genera (plus 2 unidentified protozoans) and 81 species (plus 49 unidentified and possibly identical species) have been reported. Australia is represented by 10 genera and 15 species of protozoans, and New Guinea by 1 species. Asia is represented by 1 species, present both in Japan and in Asia Minor. Europe is represented by 9 genera and 22 species. In North America, the U. S. A. records show the presence of 10 genera and 39 species, Mexico the presence of 2 genera and 2 species, Central America and adjacent South America 3 genera and 4 species, and Cuba 4 genera and 4 species. South American records show the presence of 9 genera and 46 species. The genus *Opalina* is represented by 39 species, some of which are probably duplicates. As the author has pointed out earlier (1941), *Opalina obtrigonoidea* and *O. triangularis* are probably identical, with *O. triangularis* having priority. The validity of the varietal forms of *O. hylaxena*, of *O. obtrigonoidea* (? *O. triangularis*), and of *O. virguloidea* was also questioned in the same article. *Opalina* is primarily a genus of the Western Hemisphere, although one species has invaded Eurasia. The reported presence of the genus in Australia is seriously to be doubted. The genus *Nyctotherus* is represented by 24 species, again some of which are undoubtedly cases of overlapping identifications. The genus is of New World origin, but has penetrated into Europe as *N. cordiformis* and into Australia. The identification of *N. cordiformis* in other than European hosts is to be questioned (1941). *Trypanosoma* is represented by 18 species (some unquestionably are overlapping

identifications) from Australia, Europe, North America, and South America. With the possible exception of *T. grylli,* students of the group seriously question whether any of the species reported from the *Hylidae* are other than host variants of *T. rotatorium. Cepedea,* represented by 11 species found in tropical and sub-tropical American hosts, is preëminently a South American genus. 5 species of *Protoopalina* are reported. Members of this genus are late invaders of the hylids, being found only in Europe and Australia —areas in which the hylids are relatively new invaders. The reported presence of *P. intestinalis* (a European form) in an Australian hylid is to be questioned. *Zelleriella*— with 5 species reported—is another tropical form, and thus far has been found only in the New World as far as hylid hosts are concerned. At least 8 different hosts have been reported as carrying *Balantidium* species, but as specific identifications are lacking, further comment is impossible at present. The genus *Isospora* is the only other protozoan genus with as many as 3 species that parasitize hylids. *Trichomonas augusta* in 6 host species, *Nyctotherus ? cordiformis* (U.S.A.) in 8 hosts, *Opalina chlorophili* in 6 hosts, *O. triangularis* (*? obtrigonoidea*) in 10 hosts, *O. virguloidea* in 5 hosts, and *Trypanosoma ?rotatorium* in 14 hosts, are the least host-specific species.

PROTOZOAN PARASITES

"Amoeba" sp? Australia (1)
Balantidium sp? Australia (1)
Balantidium sp? Cent. & S. Amer. (1)
Balantidium sp? Cuba (1)
Balantidium sp? Mexico & Cent. Amer. (1)
Balantidium sp? S. Amer. (1)
Balantidium sp? U.S.A. (2)
Cepedea baudinii Mex. & Cent. Amer. (1)
Cepedea brumpti S. Amer (1)
Cepedea ciliata S. Amer. (1)
Cepedea dimidiata paraguayensis S. Amer. (1)
Cepedea globosa Cent. Amer. (1)
Cepedea mogyana S. Amer. (1)
Cepedea multiformis Cent. & S. Amer. (1)
Cepedea plata S. Amer. (1)
Cepeda rubra S. Amer. (2)
Cepedea rugosa S. Amer. (1)
Cepeda sp? U.S.A. (1)
Cytamoeba grassi E. (1)
Eimeria belawini E. (1)
Entamoeba morula Australia (3)
Entamoeba ranarum Australia (1)
Eutrichomastix sp? Australia (1)
Giardia agilis E. (1)
Haemogregarina hylae Australia (1)
Hexamita intestinalis U.S.A. (2)
Hexamita sp? U.S.A. (1)
Isospora cruzi S. Amer. (4)
Isospora hylae E. (1)
Isospora wladimirovi E. (1)
Mastigamoeba hylae S. Amer. (1)
Mixidium immersum S. Amer. (1)
Mixidium lindoyense S. Amer. (2)
Myxobolus hylae Australia (1)
"Myxosporidium" sp? Australia (1)
Nyctotherus cinctus S. Amer. (1)
Nyctotherus cordiformis Australia (2)
Nyctotherus cordiformis E. (1)
Nyctotherus cordiformis S. Amer. (2)
Nyctotherus cordiformis U.S.A. (6)
Nyctotherus cordiformis hylae E. (1)
Nyctotherus cordiformis hylae U.S.A. (1)
Nyctotherus cunhai S. Amer. (1)
Nyctotherus elegans S. Amer. (1)
Nyctotherus faberi S. Amer. (1)
Nyctotherus fragilis S. Amer. (1)
Nyctotherus fulvus S. Amer. (1)
Nyctotherus gamarrai S. Amer. (1)
Nyctotherus hylae E. (1)
Nyctotherus incertus S. Amer. (1)
Nyctotherus mogyanus S. Amer. (2)
Nyctotherus ondinae S. Amer. (2)
Nyctotherus ruber S. Amer. (3)
Nyctotherus tieteanus S. Amer. (1)
Nyctotherus vulgaris S. Amer. (1)
Nyctotherus spp? Australia (2)
Nyctotherus sp? Cuba (1)
Nyctotherus sp? E. (1)
Nyctotherus spp? N. Amer. (3)
Nyctotherus sp? S. Amer. (1)
Opalina chlorophili U.S.A. (6)
Opalina elongata Cent. & S. Amer. (1)
Opalina elongata S. Amer. (2)
Opalina faber S. Amer. (1)
Opalina guatamalae Mex. & Cent. Amer. (1)

Opalina helenae Cent. & S. Amer. (2)
Opalina hylaxena U.S.A. (3)
Opalina hylaxena georgiana U.S.A. (1)
Opalina hylaxena mexicana U.S.A. (1)
Opalina hylaxena orbiculata U.S.A. (1)
Opalina hylaxena parvinucleata U.S.A. (1)
Opalina longula S. Amer. (1)
Opalina moreletei Cent. Amer. (1)
Opalina nebulosa S. Amer. (1)
Opalina oblanceolata U.S.A. (1)
Opalina obtrigona Asia Minor (1)
Opalina obtrigona E. (1)
Opalina obtrigona Japan (1)
Opalina obtrigonoidea U.S.A. (4)
Opalina obtrigonoidea orbiculata U.S.A. (1)
Opalina oregonensis U.S.A. (1)
Opalina pickeringii U.S.A. (2)
Opalina raddiana S. Amer. (1)
Opalina septentrionalis Cuba (1)
Opalina terrae-mariae U.S.A. (1)
Opalina triangularis U.S.A. (5)
Opalina virguloidea Mexico (1)
Opalina virguloidea U.S.A. (3)
Opalina virguloidea macronucleata U.S.A. (1)
Opalina virguloidea micronucleata U.S.A. (1)
Opalina sp? Australia (1)
Opalina spp? E. (3)
Opalina spp? S. Amer. (5)
Opalina spp? U.S.A. (4)
Protoopalina adelaidensis Australia (1)
Protoopalina australis E. (1)
Protoopalina hyalarum E. (1)
Protoopalina intestinalis Australia (1)
Protoopalina intestinalis E. (1)
Protoopalina papuensis New Guinea (1)
Retortamonas dobelli U.S.A. (1)
Scyphidia sp? U.S.A. (1)
Trichomonas augusta Mexico (1)
Trichomonas augusta U.S.A. (6)
Trichomonas batrachorum E. (1)
Trypanosoma borrelli S. Amer. (1)
Trypanosoma grylli U.S.A. (1)
Trypanosoma hylae E. (1)
Trypanosoma rotatorium E. (1)
Trypanosoma rotatorium S. Amer. (2)
Trypanosoma rotatorium U.S.A. (4)
Trypanosoma rotatorium major S. Amer. (1)
Trypanosoma spp? Australia (4)
Trypanosoma spp? E. (3)
Trypanosoma spp? S. Amer. (3)
Trypanosoma spp? U. S. A. (3)
Zelleriella hylaxena S. Amer. (1)
Zelleriella venezuelae S. Amer. (1)
Zelleriella sp? Cuba (1)
Zelleriella sp? S. Amer. (1)
Zelleriella sp? U.S.A. (1)

One member of the annelid group has been reported from 9 different species of the Neotropical *Hylidae*.

Schmardaella lutzii. 4 host species from Central and adjacent South America. 1 host species from Cuba. 2 host species from South America.
Schmardaella sp? (probably *S. lutzii*). 2 different host species from South America.

Three genera and 4 species of larval ticks have been recorded as feeding on 3 different host species of New World hylids.

**Acariscus mansoni* U.S.A. (1)
**Eutrombicula yorkei* S. Amer. (1)
**Hannemania hylae* U.S.A. (1)
**Hannemania newsteadi* S. Amer. (1)

Larval dipterans are reported from Australia and Europe (2 genera and 2 species) as parasitic in members of the *Hylidae*.

**Batrachomyia* sp? Australia (1)
**Lucilia bufonivora* E. (1)

One hemipteran is reported as feeding on a North American hylid

Triatoma sanguisuga ambigua U.S.A. (1)

Two genera and 2 species of bacteria have been isolated from host lesions, one from Cuba and one from Europe. *Borrelia cubensis* n. comb., is suggested for *Spirochaeta cubensis* Hoffman, 1923, inasmuch as the genus *Spirochaeta* s.s. is now reserved for the nonparasitic members of that group of organisms.

Borrelia cubensis Cuba (1)
Micrococcus batrachorum E. (1)

One mold has been isolated from skin lesions on a South American species of *Hyla* (*H. rubra*).

Dermosporidium hylarum S. Amer. (1)

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AN INVESTIGATION OF SOME POSSIBLE SOURCES OF TRICHINA INFECTION IN A CENTRAL ILLINOIS COMMUNITY

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According to Chandler, 1944, the incidence of infection by *Trichinella spiralis* is lower in the "Grain Belt" than in other regions of the United States. He suggests that the incidence of infection in both man and hog is correlated with methods of feeding hogs in different parts of the country. We have been unable to find recent publications relevant to possible sources of infection in this area. Because we were unable to find published data for this area, this study was conducted.

We have found data published in the last ten years giving the following percentages in the regions named: Kerr, 1940, found 14.5 percent human infection in the South; Harrell and Johnson, 1939, found 2.8 percent human infection in the grain region of the South. Kerr, Jacobs and Cuvillier, 1941, found 16.3 percent human infection along the Eastern seaboard. Gould, 1940, found 20 percent human infection in the Detroit area. Cameron, 1937-40, found 0.75 percent infection in the hogs of eastern Canada, and 0.2 percent infection in the hogs of the middle Canadian region. Koo, 1945, found 1.56 percent hogs infected, and 11 percent rats infected in China (table 1).

Most of the above surveys were based upon findings in routine autopsies. Since routine autopsies are not made in the hospitals of this area, that line of research is not practical. Since the source of human infection is the hog, we have based our study largely upon examinations of pork and pork products. Rats also were examined because of the general prevalence of rats in areas where hogs are fed. It is conceivable that under certain conditions hogs might feed upon rats. Actually, grain fed hogs probably ingest rats or parts of rats infrequently, but since rats have often been shown to harbor this nematode and since our problem was to cover possible sources of infection, we felt justified in examining muscle tissue from these rodents, and reporting our findings in this regard.

Most hogs raised in Central Illinois for market are grain fed. The pork derived from such feeding is of a superior quality and brings a better price. On the other hand, most garbage fed hogs are raised for home consumption.

On the basis of the above, and to obtain a cross section of the hogs slaughtered in this area, a small packing plant just outside of Bloomington, Illinois, was chosen as one source of material. We believe this to be a good choice because there both custom butchering for home consumption and slaughtering of market hogs are handled.

Another possible source of infection studied was pork products, both

cooked and uncooked, sold in this area. Emphasis was placed upon the canned, ready to eat meats.

Rats were the third source of infection studied. Five rat infested areas were chosen, consisting of two farms where it is known that hogs are fed garbage, and three city dumps where garbage is dumped and burned or fed to hogs. These dumps receive the residential garbage from a community of 40,000 people. These areas were chosen because of the marked possibility of infected pork scraps.

It seemed reasonable to assume that if appreciable numbers of trichina were present, they would be found through the study of material from these sources. We fully realize that there are other possible sources of infection, but believe that this study covers a good cross section of the sources in this area.

In the case of hogs, the diaphragms were inspected. In the case of rats, the diaphragm, masseter and gastrocnemius muscles as well as the intestinal content were examined. In the case of pork products, sample portions were inspected.

The detailed examinations were carried out as follows:

1. Microscopic examination for larvae:—A thin slice of the diaphragm or other muscle tissue was placed between two slides and compressed, thus facilitating microscopic study of the specimen.

2. Digestion of muscle tissue with subsequent microscopic examination for larvae:—The tissue was digested by a modified Baermann method. A solution of 0.5 cc. HCl, U.S.P. plus 0.7 gm. pepsin diluted to 100 cc. with water was used. The tissue was cut into small particles and placed into the solution, kept at a constant temperature of 36.5° C., with occasional shaking for a period of four hours. The solution was then centrifuged and the residue examined microscopically.

3. Examination of the intestinal content of rats for adults:—The small intestine was stripped and the contents mixed with 0.85 percent saline solution in a petri dish. This preparation was then examined under a low power, binocular microscope. When suspicious areas were seen, these were placed upon a microscopic slide and studied under a compound microscope.

In cases where immediate examination was not practical, material was stored in a 0.85 percent saline solution or 1-2-3 solution prepared by mixing 1 part 95 percent ethyl alcohol, 2 parts glycerine, and 3 parts water.

A total of thirty-seven hog diaphragms were examined using the direct microscopic method in all cases, and in a majority of cases the digestion method was used as a check. None of the diaphragms were found to be infected.

Thirty-two rats were studied. In all cases the diaphragms were examined by the direct microscopic method. In a majority of cases these findings were checked by the digestion method, using the diaphragm, masseter, and gastrocnemius muscles. An additional check was made through the inspection of the intestinal content for adults. None of these examinations showed trichina to be present.

Ten samples of meat products were studied by the direct micro-

scopic and digestion methods. The products examined were the following: lunch tongue, potted meat, deviled ham, liver spread and sausage. None of these products were found to harbor this parasite.

On the basis of the above findings, we can conclude that there is little, if any, possibility of trichina infection in the human from the sources studied in this Central Illinois Community.

TABLE 1.—COMPARISON OF INCIDENCE OF TRICHINA INFECTION IN REGIONS OF THE WORLD

Organism	Human		Hogs		Rats	
Regions	No.	%+	No.	%+	No.	%+
Cen. Ill.....			37	0	32	0
Detroit Area	500	20				
Middle Canada...			995	.02		
E. Coast....	3000	16.3				
Eastern Canada...			2000	.75		
South.....	4631	14.5				
M. South...	99	2.8				
China.....			320	1.56	47	11

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STUDIES OF THE SEX-ORGANS OF MATING POLYGYRID LANDSNAILS

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This paper is the sequel of earlier studies (Webb, in press, *Naut.*). Aside from describing and figuring the functional form of the sex-organs in mating-anatomies[1] and discussing the mating-behavior, some of the evolutionary and taxonomic implications of the data are mentioned. Also the relationships of the *Euchemotrema* (Archer 1939 a, b) to the typical *Stenotrema* species are somewhat strikingly indicated by the present data, although conclusive results will require the study of many more species.

Supplementary more-detailed data on the methods used in obtaining the observations, matings, and the mating-anatomies, will be found in the Amer. Nat. (Webb, 1947). In regard to the choice of species to be studied, opportunity has been determinative. It has just so happened that specimens of these species have been available for study and sufficient data have accumulated to permit publication. Thus the particular interspecies comparisons which have been occasioned are not as satisfactory as could be desired had specimens of a larger array of *Stenotrema* been available. The much enlarged sketch-figures were drawn from the freshly-obtained a n a t o m i e s; the other figures were from projection-tracings (inversion uncorrected) of unstained toto-mounts preserved in canada balsam (the scale-lines represent 2 mm.)

[1] Definition: the anatomies of snails exhibiting the sex-organs in the extruded, functional condition.

Stenotrema hubrichti Pilsbry 1940

The material was collected August 23, 1945, about .5-1 mile south of the type locality near Aldridge, Union County, Illinois. About 27 specimens were obtained, half being juveniles; most of the specimens were taken actively crawling about because of rain. Under the over-hanging portions of the cliff-habitat of the species, flat spider-webs yielded several living, aestivating, specimens of this and other snails. The species thrives and breeds readily in captivity, and in the laboratory at least one generation has matured from eggs deposited by the adults. The species was considered a Pleistocene form until its discoverer found some living specimens (Hubricht 1943). All of the available information would seem to indicate that this is either a relict or a suddenly, newly arisen, species.

MATING

A pair of specimens was first noted October 9, 1945 head-on (in the courtship-position) each with dilated genital pore but mating was not noted to occur until the 11th when 4 pairs of specimens previously held in isolation from others of their species were placed together at 4:30 P.M. At 8:05 P.M. a pair was noted in the head-on position; these soon separated. Later, another or the same pair was noted in a head-on

position clinging to the cover-glass; the genital pore of each animal was prominent and dilated, and from one a papilliform body was outthrust intermittently about 1 mm. A few seconds later, the snails shifted their bodies slightly and the sex-organs everted-protruded,[2] simultaneously entwining. The organs were separated and retracted within about a minute. The glimpse of the organs indicated a vermiform penis, but this is not exactly the case.

Courtships continued to be noted, but no more matings were witnessed until the 24th when 6 specimens were placed together experimentally for observations. One of these snails was noted to have a swollen, slightly-protruding genital pore. After a short interval, one specimen was noted crawling suspended from the cover-glass in such direction that it would probably contact a resting animal head-on. Such contact occured. The inactive animal "awakened," protruded-everted the tentacles, and for a short period the two animals remained head-on with the but moderately extended tentacles separated by only a slight distance. A period of head-swaying then ensued in which each animal's superior tentacle is held nearly immobile, but is caused by head movements to oscillate through a short arc opposite the corresponding tentacle of the mate-animal. Seldom is the movement so great as to cause the left tentacle of one snail to move past the right tentacle of the other; instead, the two left tentacles oscillate in apposition, and the two right tentacles oscillate in apposition. The homologous tentacles of each snail thus oscillate from side to side in apposition but seem almost never to brush together or to collide although the intervening space is much less than 1 mm. The inferior tentacles move similarly but less strikingly. During this head-swaying, tentacle-oscillation period, the genital pore of the ex-resting animal became tumid, dilated, and an irregular body became slightly extended therefrom. The crawling snail had progressively shortened its tentacles coincident with a decelerating closer approach; and during the ensuing period of vigorous tentacle-oscillation, its tentacles "arced" in a shorter condition than in the previous period. The genital pore of each animal had by now been completely dilated and both exhibited therefrom a slightly extrudent, irregular, fleshy body. The snails then moved so that the genital pores became nearly contiguous, and the sex-organs were vigorously everted-protruded, entwisting simultaneously. Mating - anatomies were secured by plunging the couple into boiling water. The resultant anatomies, however, were found to be disfigured from the effects of being drawn against the aperture during the fixation process.

The additional matings observed do not differ essentially from that described above. The shifting of the animals' foreparts to bring the genital pores into proximity is sometimes very swiftly accomplished, and possibly may be correlated with the detection by the inferior tentacles of some odor accompanying the dilation of the mate-animal's genital pore.

[2] Since the sub-terminal parts of the penis evert and cause the protrusion of the apical pilaster which forms the penis-capsule and adjacent parts, the organ is both everted and protruded. This is indicated by the compounded term. Only in *S. hirsutum* is the penis solely everted.

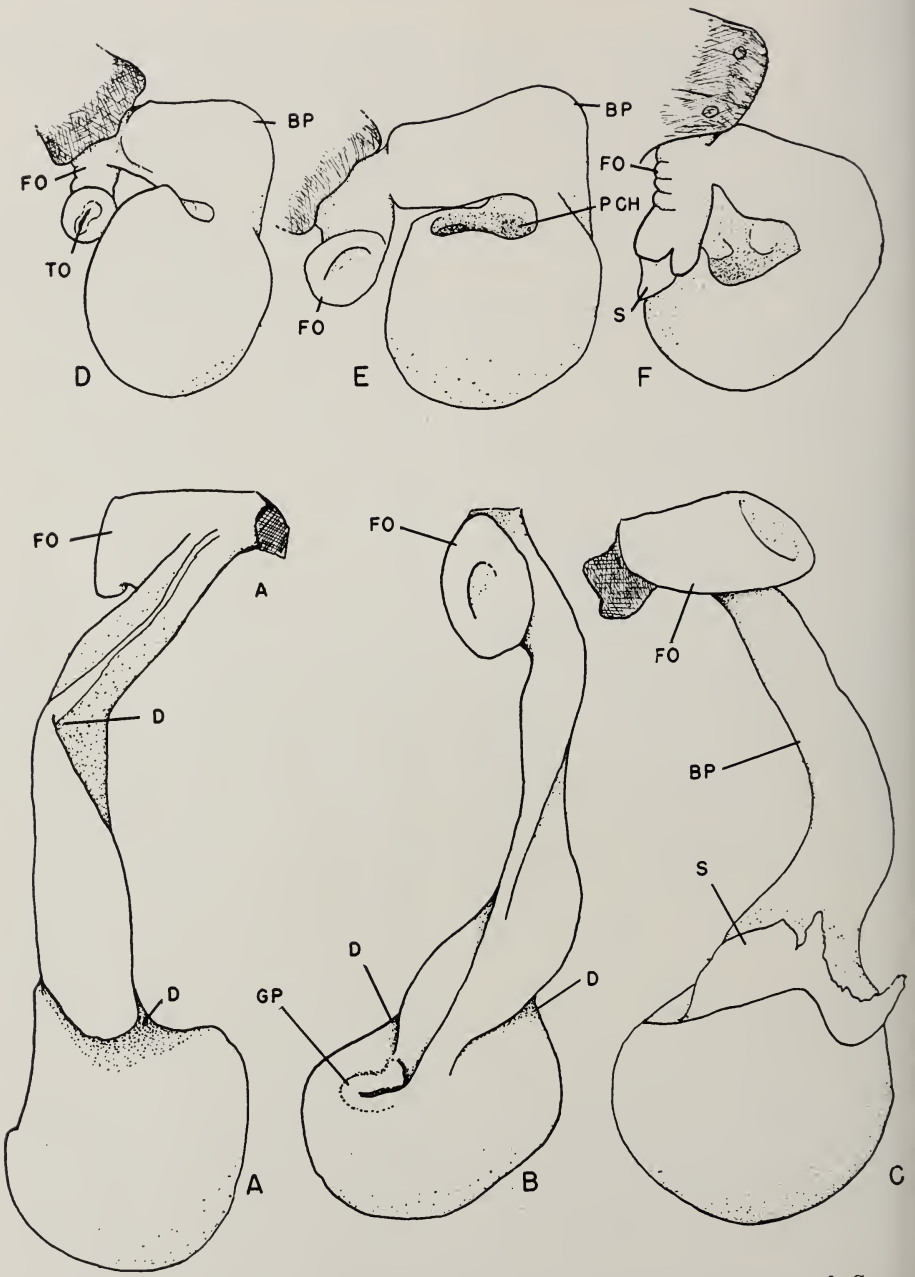

FIG. 1.—*Stenotrema hubrichti* Pilsbry, Aldridge, Illinois. A, B, and C are successive views of a deformed mating-anatomy; D and E are seemingly normal mating-anatomies; F is another specimen. Explanation of symbols: A—atrium BP—basal penis, D—deformation, FO—female-organ, GP—granular patch, PCh—penis chalice, S—semen, TO—terminal orifice of female-organ.

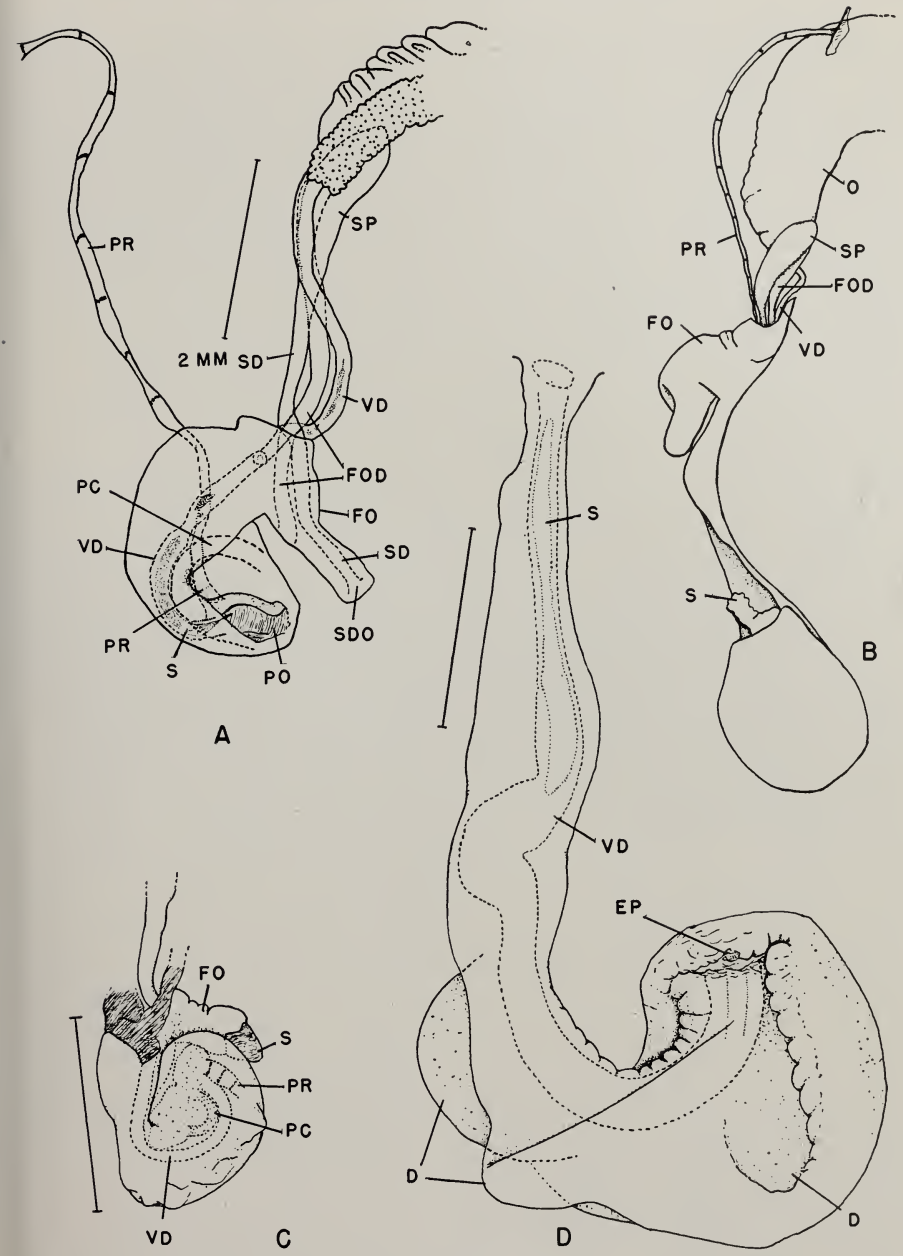

Fig. 2.—A—*Stenotrema monodon* (Rackett) Brown's Lake, Michigan, mating-anatomy; B—*S. hubrichti*, a deformed mating-anatomy showing non-everted parts of the sex-organs; C—normal mating-anatomy; D—*S. hirsutum* (Say) Indiana, mating-anatomy. Explanation of symbols: EP—ejaculatory pore; D—deformation; FO—female-organ; FOD—free oviduct; O—oviduct; PC—penis-capsule; PO—pocket of penis; PR—penis retractor; S—semen; SD—spermathecal duct; SDO—spermathecal duct orifice; SP—spermathecum; VD—vas deferens.

An explosively sudden eversion (or eversion-protrusion) of the sex-organs entwistingly is beginning to appear to be a common characteristic of polygrin landsnails; Gerhardt (1933, 1939) and others have indicated its commonality in limacids—the snail group having the mode of functioning of the sex-organs most like that of our Polygyrinae. These groups may have a greater phylogenetic commonality than has been thought to be the case. The extrusion or bulging of a body from the genital pore prior to the appearance of the entire penis seems not to be of regular occurrence in *S. hubrichti.*

Adequate data on the duration of sex-organ engagement has not been obtained. However, one pair of specimens was noted to maintain the engagement of the sex-organs for 15 seconds. This pair then started another courtship, but further observations could not be conducted at the time. Possibly sperm-transfer had not been effected successfully during the period of contact.

MATING-ANATOMY DATA

Seven mating-anatomies have been available for study.

ATRIUM

The atrium seems more conspicuous in mating-anatomies than in the retracted genitalia and forms about 1 mm. of the basal portion of the sex-organ on which both penis and female-organ[3] depend.

FEMALE-ORGAN

In the various mating-anatomies examined, twice the female-organ was found nearly or completely noneverted. The everted female-organ was found to extend .5-1.5 mm. free of the atrium and to be about .5 mm. wide. Structurally the female-organ seems formed entirely by the slightly expanded, evertable vagina and the descended spermathecal duct. None of the anatomies available show other than a terminal orifice, although the orifice of the free oviduct and of the spermathecal duct appear as two pits in this terminal orifice of the female-organ. In this regard the female-organ of this species differs from that of either *fraternum* or *monodon* in which the greater degree of eversion of the spermathecal duct also brings the orifice of the free oviduct to the exterior as a lateral orifice of the female-organ.

The incomplete or noneversion of the female-organ in *hubrichti* is suggestive that the organ is retractable or evertable independently of the penis. Subsequent eversion seems the more probable in view of the fact of penis-entwistment; since, if the female-organ is to occupy the cavity in the penis-tip, this seemingly could not occur until after the completion of the eversion-protrusion and entwistment of the penises.

Semen has been found adhering to the tip of the female-organ in several anatomies.[4]

PENIS

Early in the studies, the frequent deformation of the penis in mating-

[3] Because of the disconformity in nomenclature and function among the various organs composing the female parts of the sex-organs (the vagina, basal spermathecal duct, and the oviduct may form a single functional organ), the term "female-organ" has been adopted for the female parts of the extruded sex-organs collectively.

[4] No attempts to observe sperm have been made; the material has been identified as seminal because of its similarity to matter in the vas deferens.

anatomies caused some misconception of its true form; however, seemingly undeformed penises (fig. 1 D, E, F, and fig. 2 C) have been obtained by precrushing the shell before plunging the mating specimens into the boiling water. In freshly fixed material, the greatest length of the deformed penis was found to be 10 mm., and the greatest width (which is at the tip) about 2.5 mm. (fig. 2B). Straightening, basal constriction and shell-lip and denticle impressions are some of the penis-deformations noted (fig. 1, A, B, C).

In apparently normal mating-anatomies, the penis is cylindrical with a low, spiral twist of nearly 360 degrees. The penis-tip is rounded and slightly more inflated than the basal penis and bears subterminally a small chalice which is formed by a thickened capsule-like body as in *fraternum* and *monodon*. In *hubrichti* this penis-capsule seems least developed and is about one-fourth the volume of the entire penis. I have not been able to discern clearly an ejaculatory furrow, but such may be present. A part of the rim of the penis-chalice is noticeably more opaque and granular than the surrounding tissues in the fresh material, but this does not show so clearly in the toto-mounts. I have not happened to note a similar opaque-granular area in *monodon* or *fraternum* but perhaps the careful observation of fresh material would reveal it.

Stenotrema monodon (Rackett)

For most of the material, I am indebted to the late Dr. Phil L. Marsh. The material was labeled "N. Shore of Brown's Lake, Jackson Co., Michigan, 10-12-1941." Some observations on matings have also been obtained from specimens collected in the fall of 1945 about Muskelunge Lake, near Warsaw, Kosciusko County, Indiana.

MATING

The Michigan material was received October 16, 1941, and specimens were observed mating on the 17th. In courtship the animals are head-on with the extreme anterior end protruded in a peculiar fashion, as in courting specimens of *fraternum*. This constricted appearance of the extreme anterior parts seems due partly to a tumefaction of the body parts above and posterior to the genital pore. Eventually a dilation of the genital pore occurs and the rest of the courtship and mating resembles that of *fraternum*, with the animals mouthing or gnawing at or about a lobular body protruded from the mate-animal's genital pore. Sperm transfer is accomplished when the penises are suddenly everted-protruded and the female-organ comes to be enveloped by the penis-capsule. (The exact procedure is obscure. It appears more probable that the female-organ is everted into the penis-capsule, than that the capsule engulfs the female-organ.) The disengagement of the organs seems to follow sooner in this species than in *fraternum*. One pair was noted of which one animal pivoted before mating ended the courtship. The mating anatomies of this pair revealed the female-organ of each to be engaged reciprocally in the mate's penis-chalice.

In contrast to *fraternum*, gnawing, biting, and pivoting acts have been observed to occur much more rarely,

but too few observations are at hand to justify the conclusion that a difference in behavior exists.

MATING-ANATOMY DATA

Only two pairs of mating-anatomies have been available for study, although the extruded organs of several additional pairs have been momentarily glimpsed in life (fig. 2A.).

ATRIUM

This is not a sharply differentiated part of the extruded sex-organs, but presumably forms the parts adjacent to the genital pore area.

FEMALE-ORGAN

This appears slimmer and without the low annulations exhibited in *fraternum* and does not project from beneath a low fold as in that species; both a terminal orifice (spermathecal duct) and a lateral orifice are present.

PENIS

This is similar in general form to that of *fraternum* but differs in the following details: it is more ellipsoid and less globular in shape, bears a smaller penis-capsule forming a smaller penis-chalice, and lacks the slight ridge overhanging the female-organ and basal penis. The internal structure of the penis-chalice in *monodon* also differs in having a wide, shelf-like pocket instead of a sinuous, ejaculatory fissure. The orifice of the penis-chalice is triangular or elongate in *monodon* whereas it is rounded in *fraternum*.

Stenotrema hirsutum (Say)

Most of the material was collected in Indiana in 1939 or 1940, presumably near Indianapolis. While the shells of some of the specimens seem identical with the material from Indianapolis which Pilsbry (1940, p. 658, fig. 409a) designates as *S. stenotrema* (Pfeiffer), I am not convinced that a central Indiana population exists which is specifically separable from the local *hirsutum*. Some will prefer to regard the material studied, however, as a mixture of *hirsutum* and *stenotrema*. One mating and a pair of mating-anatomies were obtained from material collected on the hillsides of Big Bureau Creek, within 2 miles upstream of the route 26 bridge near Princeton, Illinois.

MATING

The first complete observations on mating were made November 27, 1940, when specimens were noted crawling about suspended from the cage cover-glass. The specimens formed courting couples which separated and reformed with new or old partners. The specimens crawled actively, waving the tentacles, and frequently pivoting. Prior to mating, two specimens were noted head-on with the genital pore dilated and forming a curved swelling. When the edge of the swelling of one snail touched that of the other, the penises were reciprocally everted entwiningly.

In the pair of Bureau County specimens observed October 22, 1945 (uncontroversially *hirsutum*), the courtship started with a circling movement of one animal following the tail of the other. After being in a head-on position, pivoting ensued and the animals discontinued activi-

ties. Shortly thereafter, another or the same pair were noted in courtship. In these a reciprocal spiraliform movement occurred clockwise (the animals were suspended from the cage cover-glass) such that the head of one animal was opposite the non-genital pore side of the other, and the bodies were bent nearly at a right angle. Pivoting by both animals followed. The snails failed to rejoin head-on but resumed the spiraliform, reciprocal circling as before. One animal pivoted (possibly because of a mild gnawing by the other against the side of the foot or body) and the genital pore was seen to be slightly prominent as a pimple-like swelling. The specimens continued these maneuvers until they happened to rejoin head-on, each with the genital-pore bulging convexly. As soon as the animals were close enough together to contact with the fore parts of the genital swelling of the mate-animal, the penises everted entwiningly; the animals were still suspended from the cover-glass by the foot as before. Exclusive of the first, interrupted courtship, the courtship is estimated to have lasted about half-an-hour. Biting was not noted, but a gentle rasping on the side of the foot may have occurred. These specimens had been kept in isolation from others of the species until they were placed together for possible matings.

MATING-ANATOMY DATA

None of the four mating-anatomies obtained probably have been free of the deformations which result from the wedgement of the extruded sex-organs against the aperture during fixation (fig. 2D).

ATRIUM

This is continuous with the basal part of the penis and is not discernable from it.

FEMALE-ORGAN

An everted female-organ has not been found in any mating-anatomy. Other evidence of the nonevertability of this organ is the absence of a thickened vaginal duct, basal spermathecal duct, and free oviduct; in *monodon*, *fraternum*, and *hubrichti* these ducts are noticeably thickened and muscular in the retracted organs. Some other Polygyrinae are known to have nonevertable female-organs, as *Mesodon thyroidus* and *M. elevatus*.

PENIS

Despite more or less disfigurement, the essential form of the penis seems to be that of a tapering, somewhat flatsided sac bearing the ejaculatory pore distally. The pore opens to the exterior centrally on the tip of the penis. A strand of seminal matter protrudes from the pore in one anatomy. No capsule, chalice, or comparable structures are present. The entire penis has a curved or spiraliform twist. Were the recurved penis-tip to become fused with the midportion, a condition somewhat analogous to that in *hubrichti* would result, except that a penis-capsule and a female-organ would yet be lacking.

Conclusions

In the *Euchemotrema* (subgenus) studied, all have a similar type of mating-behavior. Pivoting is not a frequent and prominent part of the

mating-actions; this probably is due to the infrequency of biting or other extremely stimulative actions, and to the slow head-on approach utilized which prevents the attainment of positions unfavorable to mating. *S. hubrichti* seems to have the most quiet type of mating-behavior with seemingly the complete absence of biting or gnawing actions, and is characterized by the elaborateness of the head-arcing process in courtship.

In the *Stenotrema* (subgenus) studied, *hirsutum* and/or *stenotrema*, the behavior differs from the preceding group in the greater activity of the animals with the greater part of the courtship period being occupied with rotations, spiraliform-movements, and pivoting, rather than a very slow, head-on approach.

From the standpoint of sex-organ anatomy, *fraternum*, *monodon*, and *hubrichti* seem to exhibit modifications of a common basic type. The slight specific differences between *monodon* and *fraternum* anatomically may be useful in varietal and species diagnosis, although some of the many varieties of these two species may be found to exhibit transitional types. Phylogenetically *hubrichti* would seem to be the most divergent of the three species. The apical, globular pilaster noted by Archer as characterizing the *Euchemotrema* is the seeming homologue of the penis-capsule, and would seem to be a more important criterion than penis-length. In the lack of female-organ and penis-capsule, *hirsutum* (subgenus *Stenotrema*) would seem to be rather divergent from the preceding.

The sex-organ structure of these species seems to illustrate possible sex-organ barriers to panmixy. Thus *monodon* and *fraternum* might be expected to cross-mate, but *hubrichti*, because of entwistment, would seem apomixic to these other two species. In regard to *hirsutum*, *hubrichti* might be panmixic anatomically since an entwistment of penises between these two species conceivably might accomplish sperm-transfer; however, the differences in mating-behavior would probably prevent the courtship from arriving at the entwistment stage. The present data strongly suggest the presence of sex-organ barriers and mating-behavior barriers to panmixy to varying degrees within the polygrin genus *Stenotrema*. Such barriers in all likelihood have influenced and continue to influence the evolution and speciation of these snails.

Summary

1. The form of the sex-organs in the extended, functional condition, the mating behavior, and the evolutionary significance of the data are given for *Stenotrema hirsutum* (Say), *S. hubrichti* Pilsbry, and *S. monodon* (Rackett) in comparison to *S. fraternum* (Say).

2. The form of the sex-organs of *monodon* appear essentially as in *fraternum*, but the penis is more eliptical, the penis-capsule smaller, and the female-organ slimmer and less ornate. *Stenotrema hubrichti* differs from *monodon* and *fraternum* in having a stalked penis, a more-reduced penis-capsule, and lateral-poreless, much smaller female-organ. The sex-organ of *hirsutum* differs markedly from that of the preceding species in lacking a female-organ, and in having a simpler, tubular-

spiraliform penis which has a terminal ejaculatory pore, but no capsule or chalice.

3. The mating-behavior of *monodon* is essentially like that of *fraternum,* but *hubrichti* differs slightly in the exaggeration given the arcing process of the head-and-tentacles, and in the absence of biting during mating. Almost constant maneuvering with fleeting periods of the head-on position characterizes the mating-behavior of *hirsutum.*

4. Sperm-transfer in *monodon* and *fraternum* is accomplished by the sudden eversion-protrusion of the penis and deposition of seminal material on the everted female-organ which occupies the penis-chalice. In *hubrichti* an entwistment of the everting-protruding penises occurs, but it appears probable that otherwise sperm-tranfer is accomplished similarly. In *hirsutum* the lack of a female-organ modifies sperm-transfer in necessitating the use of the penis also in securing the exchanged or shared semen.

5. Evolutionarily, *fraternum* and *monodon* seem least likely of the species studied to have an effective sex-organ difference barrier to panmixy; *hubrichti* does seem to have a sex-organ difference barrier to panmixy with the preceding, and also possibly with *hirsutum.* While seemingly apomixic to *monodon* and *fraternum,* possibly *hirsutum* has only a behavior barrier to panmixy with *hubrichti.*

6. The present data indicate that sex-organ differences affecting panmixy probably exist among the species of the polygyrin genus *Stenotrema,* and in all likelihood have influenced the evolution and speciation of these snails.

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ADDITIONAL RECORDS OF ILLINOIS MAMMALS

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The records of distribution of mammals of Illinois were last summarized by Necker and Hatfield in 1941. Since that time relatively few records of Illinois mammals have appeared and these data are scattered through the literature.

Specimens reported by Koestner (1941a and b; 1942) had been recorded by Necker and Hatfield through correspondence with Koestner. Goodnight and Koestner (1942) recorded mammals found in the general area of a quadrat study near Seymour, Champaign County; however, this list included no new county records, with the possible exception of a sight record of the red fox.

Bole and Moulthrop (1942) cited records which were new for the short-tailed shrew, *Blarina brevicauda,* from Bloomington, McLean County; the prairie meadow mouse, *Microtus ochrogaster,* from Ozark and Reevesville, Johnson County, and from Bloomington; and the lemming vole, *Synaptomys cooperi,* from Bloomington.

Mohr discussed the distribution of Franklin's ground squirrel, the thirteen-lined ground squirrel, the woodchuck (1943), and the prairie mole and pocket gopher (1946) but did not cite actual specimens. Mohr's discussion (1941) of the distribution of Illinois mammals was without citation of actual specimens.

This paper is an effort to summarize records from collections made since 1941, as well as a few records prior to that time which were not cited by Necker and Hatfield. These records were obtained from lists of collections supplied by the Chicago Natural History Museum, the Museum of Zoology of the University of Michigan, and the Department of Zoology of the University of Wisconsin; from examination by the writer of the collections of the Illinois State Natural History Survey, Normal State University, and the University of Illinois Natural History Museum; from the writer's collection; and from certain records obtained from the literature since 1941.

I should like to express my appreciation for the cooperation of the following institutions and more specifically to individuals at these museums: D. F. Hoffmeister, University of Illinois Natural History Museum; C. O. Mohr, Illinois State Natural History Survey; C. C. Sanborn, Chicago Natural History Museum; H. K. Gloyd, Chicago Academy of Sciences; W. H. Burt, Museum of Zoology, University of Michigan; Orlando Park, Department of Zoology, Northwestern University; J. T. Emlen, Jr., Department of Zoology, University of Wisconsin; and M. R. Lamkey, Normal State University, Normal, Illinois.

The collection of the State Natural History Survey included many unpublished records from recent collections, made largely by C. O. Mohr; and many old specimens either not specifically cited by Wood (1910) or not recorded in literature

at all. These latter groups contain specimens collected by Wood, Gross, and others and date back to 1877. The material at Normal University consists largely of old collections by the Natural History Survey when located at Normal and of remnants of the Major J. W. Powell collection.

There have been few literature citations of records of mammals collected from the western part of Illinois. The following list records for that part of the state many of the common mammals, as well as more noteworthy records such as the lemming vole, *Synaptomys cooperi,* and the eastern meadow mouse, *Microtus pennsylvanicus.*

The Carolina shrew, *Sorex longirostris longirostris,* has heretofore been reported only for the southernmost portion of Illinois, in Alexander and Johnson counties, with the exception of a possible record by Wood for Pistakee Bay, McHenry County. In 1946 Mohr obtained a specimen from Fox Ridge State Park in Coles County. This record extends the range of this southern shrew to at least central Illinois.

On the basis of literature citing specimens actually on deposit in museums, the cinereous shrew, *Sorex cinereus cinereus,* has been recorded only from northern Illinois in Cook, Lake, and Kankakee counties. Specific reference is made in the following list to a specimen collected at Normal, McLean County, now on deposit at the Illinois State Natural History Survey. This specimen was collected in 1877 and probably formed the basis of the McLean County record of Wood.

Existing records of the lemming vole, *Synaptomys cooperi,* have been restricted to Crawford and Hardin counties to the south and Vermilion and Champaign counties in east central Illinois. In the fall and winter of 1946 trapping for this microtine was stimulated at the University of Illinois by the capture of two specimens near LeRoy, McLean County, by D. F. Hoffmeister; two specimens at Kickapoo State Park, Vermilion County, by the writer; one specimen four miles east of Urbana by Dean Ecke, a University of Illinois student; and the discovery in a quadrat study by D. G. Allison and the writer of a high population of *Synaptomys* in the extensive undisturbed blue-grass areas of the Allerton Tract, five and one-half miles west of Monticello, Illinois. Hoffmeister (1947) continued study of the *Synaptomys* population on the Allerton Tract. As a result of this large population of the lemming vole, the number of specimens in the University of Illinois Natural History Museum is still increasing. In addition to these collections, recent specimens obtained by Mohr and by Sanborn and Eigsti, Chicago Natural History Museum, indicate a probable statewide, although spotty, distribution of this vole.

The distribution of the eastern meadow mouse, *Microtus pennsylvanicus pennsylvanicus* has been recorded largely as restricted to northern Illinois. Through no fault of Necker and Hatfield, two *Synaptomys cooperi* from Muncie, Vermilion County, were reported (1941) as *M. pennsylvanicus.* Mohr pointed out this discrepancy, and I have verified that the report is in error by examination

of the two specimens in alcohol on file at the Natural History Survey. In April 1947, six *M. pennsylvanicus* were trapped in a blue-grass pasture, which has been ungrazed for over seven years, two miles southeast of Good Hope, McDonough County. In this area *M. ochrogaster* was trapped at the same time and in approximately equal numbers. A record of *M. pennsylvanicus* for Warren County was obtained from the Natural History Survey collection; the specimen is No. 38328 (skull only) and was collected February 12, 1908, at Monmouth. In addition, three specimens in alcohol at the Survey were collected at Normal in 1877 and 1878 and probably form the basis of Wood's McLean County records.

In general, the occurence of *M. pennsylvanicus* in Illinois appears to be nearly statewide, with the possible exclusion of the southern portion of the state. However, due to the early dates of many of the records and since present capture in central Illinois is restricted almost entirely to long undisturbed areas, the present distribution in Illinois is probably almost as spotty as is indicated by the actual records.

The restricting effects of agriculture and other efforts of man which have altered the natural prairie and forest-edge of the state is evident in the above mentioned distribution of *M. pennsylvanicus* and *S. cooperi*. This is probably more graphically seen in examination of records for the meadow jumping mouse, *Zapus hudsonius hudsonius*. Wood had no specimens of the jumping mouse and stated that it was apparently much rarer in the state than formerly, and perhaps on the verge of extinction. Necker and Hatfield cite specimens from Cook, Jackson, Jo Daviess, Kane, Lake, and Marshall counties. From Wood's statements and those of Mohr (1941) and from information gained from elderly farmers, it is inferred that even in its southern range in Illinois, the jumping mouse was once not uncommon. This is somewhat borne out by the discovery of two specimens at Normal University, one from McLean County and one from nearby Woodford County, collected in 1875 and 1879 respectively. To these older records may be added a sight record by the writer in 1929 for McDonough County. Also, a jumping mouse was captured in a Sherman live trap on a population study grid-quadrat of the writer's at Kickapoo State Park, Vermilion County, in April, 1941. This particular area had been strip-mined approximately thirty years earlier and had received little further disturbance from man since that time.

Additional Records of Mammals in Illinois

An effort has been made to be extremely conservative in listing these records of mammals for Illinois, and in many cases subspecies have not been mentioned. In some cases this is due to unsettled taxonomy of a particular genus and in others to the probability of the specimens being intergrades which have not been sufficiently studied to permit subspecific determinations. In listing the localities the general plan of that used by Necker and Hatfield is followed. In addition, the number of specimens on deposit is listed and in the cases in which a specimen is not

made up as study skin and skull, the condition of the specimen is indicated. The accession numbers, dates, and collectors are given, when available, for records of especial interest. The list of localities includes specimens in collections designated as follows:

ClM—Cleveland Museum of Natural History, Cleveland, Ohio
CNHM—Chicago Natural History Museum (Field Museum)
INHS—Illinois State Natural History Survey, Urbana, Illinois
M—Museum of Zoology, University of Michigan
N—Normal State University, Normal, Illinois
RMW—R. M. Wetzel, University of Illinois, Champaign, Illinois
UI—Natural History Museum, University of Illinois
UW—Department of Zoology, University of Wisconsin, Madison, Wisconsin.

Didelphis virginiana virginiana Kerr. Virginia Opossum.
Coles—Mattoon, 1 INHS. *Cumberland*—Greenup, 1 (skull only) INHS. *Fayette*—Farina, 1 UW. *Fulton*—Summum, 1 (skull only) INHS. *Jackson*—Grand Tower, 1 (skull only) INHS. *Union*—Wolf Lake, 1 (skull only) INHS.

Sorex cinereus cinereus Kerr. Cinereous Shrew.
Cook—Park Ridge, 1 (alc) INHS. *Lake*—Lake Zurich, 1 (alc) INHS. *McLean*—Normal, 1 (alc) INHS (No. 37192—Nov. 6, 1877).

Sorex longirostris longirostris Bachman. Carolina Shrew.
Coles—Fox Ridge St. Park, 1 (alc) INHS (coll. C. O. Mohr—Oct. 12, 1946).

Blarina brevicauda (Say) subspecies. Short-tailed Shrew.
Bureau—Ohio, 1 UI. *Henry*—Geneseo, 3 (alc) INHS. *LaSalle*—Starved Rock St. Park, 1 INHS. *McLean*—Bloomington, 26 Cl M (Bole & Moulthrop, 1942); Normal, 2 N, 8 (alc) INHS. *McHenry*—near Pistakee Bay, 5 (alc) INHS (Nos. 38262-4, 38275, 38277—Nov., 1907). *Stephenson*—Dakota, 1 (alc) INHS. *Vermilion*—Kickapoo St. Park, 1 CNHM, 1 RMW. *Warren*—Monmouth, 1 (alc) INHS (coll. F. E. Wood—Jan. 25, 1908).

Cryptotis parva (Say) subspecies Small Short-tailed Shrew.
Coles—Charleston, 1 INHS (No. 38241—Dec., 1903). *Iroquois*—Onarga, 1 (alc) INHS; Thawville, 1 (alc) INHS. *Mason*—Havana, 2 INHS (No. 38241— Oct. 30, 1907, & 1 alc). *Piatt*—Allerton Tract, Monticello, 2 (1 whole skelton) UI.

Myotis lucifugus lucifugus (LeConte). Little Brown Bat.
Adams—Quincy, 1 (alc) INHS. *Calhoun*—Pere Marquette St. Park, 1 (alc) INHS. *LaSalle*—Starved Rock St. Park, 1 (alc) INHS. *Monroe*—Burksville, 1 (alc) INHS. *Schuyler*—Beardstown, 1 (alc) INHS.

Lasionycteris noctivagans (LeConte). Silver-haired Bat.
Ford—Gibson City, 1 (alc) INHS.

Eptesicus fuscus fuscus (Beauvois). Big Brown Bat.
LaSalle—Peru, 7 CNHM.

Lasiurus borealis borealis (Müller). Red Bat.
Calhoun—Pere Marquette St. Park, 1 (alc) INHS. *Cook*—Maywood, 3 (alc) INHS. *LaSalle*—Starved Rock St. Park, 1 (alc) INHS. *Massac*—New Columbia, 2 (alc) INHS. *McLean*—Normal, 7 (alc) INHS. *Pope*—Bay City, 1 (alc) INHS; Herod, 1 (alc) INHS.

Nycticeius humeralis (Rafinesque). Rafinesque's Bat.
McLean—Bloomington, M; Normal, 1 (alc) INHS.

Procyon lotor (Linnaeus) subspecies. Raccoon.
Champaign—Urbana, 1 (skull only) RMW. *Cumberland*—Greenup, 1 (skull only) INHS. *Lake*—Fox Lake, 1 INHS. *Massac*—Metropolis, 1 (skull only) INHS.

Mustela frenata noveboracensis (Emmons). Long-tailed Weasel.
Livingston—Dwight, 1 (pelt only) INHS. *McLean*—Normal, 1 INHS. *Winnebago*—Rockford, 1 INHS.

Mustela vison Schreber. Mink.
Alexander—Olive Branch, 1 (skull only) INHS.

Mephitis mephitis avia Bangs. Striped Skunk.
Massac—Metropolis, 1 (skull only) INHS. *McDonough*—Good Hope, 1 RMW. *Pike*—Griggsville, 3 (pelts only) INHS.

Vulpes fulva (Desmarest). Red Fox.
Douglas—Arcola, 3 (skulls only) INHS; Reynoldsville, 1 (skull only) INHS. *Livingston*—Dwight, 2 (skulls only) INHS; Manville, 3

(skulls only) INHS. *Mason*—Bath, 1 (skull only) INHS. *Piatt*—Allerton Tract, Monticello, 1 (skull only) RMW. *Pike*—Griggsville, 2 (skulls only) INHS.

Urocyon cinereoargenteus cinereoargenteus (Schreber). Gray Fox.
Mason—Bath, 1 INHS; Havana, 1 (skull only) INHS. *Pike*—Griggsville, 1 (skull only) INHS.

Marmota monax monax (Linnaeus). Woodchuck.
Massac—New Columbia, 1 (skull only) INHS. *Ogle*—Flag Center, 1 (skull only) INHS. *Pike*—Griggsville, 1 (pelt only) INHS. *Union*—Wolf Lake, 2 CNHM. *Vermilion*—Fairmont, 1 (skull only) RMW.

Citellus tridecemlineatus tridecemlineatus (Mitchill). Thirteen-lined Ground Squirrel.
Macon—Decatur, M.

Citellus franklinii (Sabine). Franklin's Ground Squirrel.
Douglas—Arcola, 1 INHS. *Ogle*—Oregon, 1 (skull only) INHS.

Tamias striatus griseus Mearns. Eastern Chipmunk.
DeKalb—Waterman, 1 UI. *Jackson*—Murphysboro, 1 CNHM. *Lake*—Antioch, 1 (alc) INHS. Possibly the specimen from Murphysboro is referable to *T. striatus ohionensis* Bole and Moulthrop.

Sciurus carolinensis Gmelin subspecies. Gray Squirrel.
Carroll—Thomson, 1 (pelt only) INHS. *Fayette*—Farina, 1 UW. *Jo Daviess*—Galena, 1 (pelt only) INHS. *Union*—Wolf Lake, 1 (pelt only) INHS.

Sciurus niger rufiventer (Geoffroy). Fox Squirrel.
Carroll—Thomson, 1 (pelt only) INHS. *Logan*—San Jose (east), M. *Marshall*—Rutland, 1 INHS. *Massac*—New Columbia, 1 (skull only) INHS. *McLean*—Hudson, 1 N. *Pike*—Griggsville, 2 INHS; Valley City, 1 (pelt only) INHS. *Sangamon*—Lanesville, 1 (pelt only) INHS. *Union*—Wolf Lake, 2 (pelts only) INHS. *Vermilion*—Muncie, 1 (skull only) INHS. *Will*—Wheatland Tp., M.

Peromyscus maniculatus bairdii (Hoy and Kennicott). Prairie Deer Mouse.
Calhoun—Pere Marquette St. Park, 1 (alc) INHS. *Coles*—Charleston, 4 (alc) INHS (Nos. 37977, 39666, 39668, 39670—1908). *Jo Daviess*—Galena, 2 (alc) INHS. *Kankakee*—Bourbonnais, 2 (alc) INHS. *Marion*—Salem, 1 INHS. *Mason*—7 (alc) INHS. *McDonough*—Good Hope, 1 RMW. *McHenry*—near Pistakee Bay, 4 (alc) INHS. *McLean*—Normal, 1 (alc) INHS (No. 37195—May 6, 1876). *Vermilion*—Kickapoo St. Park, 4 RMW. *Warren*—Monmouth, 5 (alc) INHS.

Peromyscus leucopus leucopus (Rafinesque). White-footed Mouse.
Jackson—Carbondale, 4 CNHM.

Peromyscus leucopus noveboracensis (Fischer). White-footed Mouse.
Carroll—Thomson, 1 INHS. *Coles*—Charleston, 1 INHS. *Fulton*—Duck Island, 8 (1 w/skull only, 1 w/o skull) UI. *Madison*—Alton, M. *Mason*—Havana, 1 INHS; 1 CNHM. *Ogle*—White Pines St. Park, 2 RMW.

Neotoma floridana illinoensis Howell. Illinois Wood Rat.
Alexander—Horseshoe Lake (Olive Branch), 1 INHS.

Synaptomys cooperi Baird. Lemming Vole.
Champaign—Urbana, 2 INHS (No. 37969 alc & No. 37970—March 7, 1908), 1 UI (Nov., 1946). *Fulton*—Vermont, 1 (alc) INHS (Oct. 24, 1946). *McLean*—Bloomington, 2 ClM (Bole & Moulthrop, 1942; includes type of *S. c. saturatus*); LeRoy, 2 UI (Nov., 1946). *Piatt*—Allerton Tract, Monticello, 18 RMW (Nov., 1946 & Feb., 1947, 9 w/skulls only), 12 UI (Nov., 1946 & Feb., 1947). *Richland*—Olney, 20 (skulls only—from owl's nest) INHS (1934). *Vermilion*—Muncie, 2(alc) INHS (June, 1936. Reported by Necker & Hatfield, 1941, as *Microtus pennsylvanicus*); Kickapoo St. Park, 4 CNHM (July 21, 1942), 2 RMW (Nov. 7, 1946). *Sangamon*—Auburn, 1 RMW.

Microtus pennsylvanicus pennsylvanicus (Ord). Eastern Meadow Mouse.
Douglas—Arcola, 1 INHS. *Kane*—Sugar Grove, M. *Lake*—Waucanda, INHS (fragments of skulls). *McDonough*—Good Hope, 6 RMW (April 6, 1947). *McHenry*—tamarack swamp near Pistakee Bay, 2 (alc) INHS (Nos. 38290, 38291—Nov., 1907). *McLean*—Normal, 3 (alc) INHS (Nos. 37183, 37194, 37863—1877 & 1878). *Warren*—Monmouth, 1 (skull only) INHS (No. 38328—Feb. 12, 1908).

Microtus ochrogaster (Wagner). Yellow-bellied Meadow Mouse.
Adams—Lima, 2 INHS. *Cook*—Des Plaines, 3 UI. *Hancock*—Hamilton, 1 N (Jan., 1884). *Iroquois*—Onarga, 1 (alc) INHS. *Jasper*—Hunt, 2 (1

alc) INHS. *Johnson*—Ozark, 2 CNHM (Bole & Moulthrop, 1942); Reevesville, 2 CNHM (Bole & Moulthrop, 1942). *Madison*—Godfrey, 1 (skull only) INHS. *McDonough*—Good Hope, 4 RMW. *McLean*—Bloomington, 9 Cl M (Bole & Moulthrop, 1942); Normal, 2 N; LeRoy, 1 UI. *Piatt*—Allerton Tract, Monticello, 2 UI; Monticello, 1 (alc) INHS. *Putnam*—Putnam, 1 (alc) INHS. *Warren*—Swan Creek, 1 RMW. *Woodford*—Eureka, 3 UI.

Pitymys pinetorum (LeConte). Pine Mouse.

Piatt—Allerton Tract, Monticello, 1 UI. *Richland*—Olney, 1 (alc) INHS.

Zapus hudsonius hudsonius (Zimmermann). Meadow Jumping Mouse.

McLean—no locality, 1 N (1875). *Vermilion*—Kickapoo St. Park, 1 RMW (April, 1941). *Woodford*—Kappa, 1 N (May 24, 1879).

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COLLEGIATE SECTION

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2. Resistance Capacitance Timing Circuit: ROY RIVIERE, Wheaton College, Wheaton.
3. A Proposed College Hired Radio System: PHILIP TURRELL, Wheaton College, Wheaton.
4. A Geology Field Training Program: MARY GERALDINE BOWERS, University of Illinois, Urbana.
5. Studies on the Pennsylvanian of Wyoming: NORMA EILEEN WALLIS, University of Illinois, Urbana.
6. Electric Log Study of the Basal Pennsylvanian Sandstone, Louden Pool, Fayette County, Illinois: MARY L. WIDENER, University of Illinois, Urbana.
7. Numbers: MARIAN CHAPMAN, Wheaton College, Wheaton.
8. Pi! RUTH STAMM, Wheaton College, Wheaton.
9. Spectroscopy as Applied to Chemistry: ELLA RICHARDS, Wheaton College, Wheaton.
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11. Characteristics of the Biuret Reaction: MARGARET GRIEBEL, Mundelein College, Chicago.
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13. Comparative Study of Potassium Acid Phthalate and Sulfonic Acid as Primary Standards in Quantitative Analysis: ALVERNA PAULAN, Mundelein College, Chicago.
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15. A Complex Thiocyanate of Cobalt and Mercury: MARY LEMON, MacMurray College, Jacksonville.

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3. Student Experiences in Industry: VIRGINIA O'DONNELL, College of Saint Francis, Joliet.
4. The Housing of Married Students in a Liberal Arts College of 1500: ARLENE SHEELEY, Wheaton College, Wheaton.
5. Township Government in a Suburban County in Northern Illinois: ARTHUR MERCK and WARREN LANE, Wheaton College, Wheaton.
6. Special Banking Practices in a Suburban Community in Illinois: JAMES HOCHSTETTLER, Wheaton College, Wheaton.
7. Spectrophotometric Determination of Ascorbic Acid in Blood: PATRICIA BANN, LeClerc College, Belleville.
8. Spectrophotometric Determination of Copper and Iron in Blood: RUTHMARY POELKER, LeClerc College, Belleville.
9. A Study of the Rh Factor in the Blood: DOLORES BARTA, LeClerc College, Belleville.
10. Hydrogen Ion Concentration—A Controlling Factor in the Staining Properties of Bacteria: BETTY ANN BURNS, LeClerc College, Belleville.
11. Spectrophotometric Determination of Beta-carotene and Vitamin A in the Blood: ANNA DEAN BREYEL, LeClerc College, Belleville.
12. Key to the Genera of Agaricaceae: MARY DIEL and VERA SCHERER, Eastern Illinois State Teachers College, Charleston.
13. Color Discrimination in Fishes: RICHARD H. PICL, University of Illinois, Urbana.
14. Choice of Background Color in Fishes: ROBERT ASHBY, BILLY MESTAL, and WARD MOORE, University of Illinois, Urbana.
15. Distribution of Mollusca in the Salt Fork of the Big Vermilion River with Special Reference to Pollution: GLENN R. WEBB, University of Illinois, Urbana.
16. Comparative Study of Nuclei of some Cryptogams and Phanaerogams in both Living and Fixed Condition: PATRICIA A. CORCORAN and PATRICIA M. BRANIGAN, Mundelein College, Chicago.

MEMORIAL

ALBERT EDWARD EDGECOMBE
1897-1945

The sudden death on March 30, 1945, of Albert Edward Edgecombe at the age of forty-eight cut short the life of a man whose devotion to study and research had reached the stage where his accumulated knowledge and techniques would have resulted in maximal productiveness. He was an Englishman by birth, spent over half of his life in Canada, and became an American citizen in 1935. He was an associate professor of botany at Northwestern University at the time of his death. His research activities were largely in the field of mycology.

Albert Edward Edgecombe was born in Devonshire, England, on February 5, 1897, and succumbed to a cerebral hemorrhage at his home in Wilmette, Illinois, on March 30, 1945. He was the son of Samuel and Frances (Pennell) Edgecombe, coming to Canada with his parents when three years old. He taught in the secondary schools of Canada for several years, and served as a field agent of the Presbyterian Church in British Columbia. He was graduated with honors from Queens University, Ontario, in 1923 and received the degree of Master of Arts from the same institution two years later. He then entered the graduate school of the University of Chicago, completing the work for the doctorate in 1929. From the Chicago Law School he received the LL.B and J.D. degrees in 1934.

Edgecombe was a fellow of the American Association for the Advancement of Science, a charter member of the Mycological Society of America, and a member of Phytopathological Society, Botanical Society, American Association of University Professors, Sigma Xi, Phi Alpha Delta, and the Illinois State Academy of Science.

He married Sara Roberta Mohn of Pottstown, Pennsylvania, on November 23, 1939. His widow and two children, Phyllis and David, together with one brother living in Canada, survive him.

Edgecombe was retiring, shy, and modest to the point of self-effacement. His qualities of friendliness, generosity, and affection were reserved for his family and his intimate friends He loved the quiet of his home and the seclusion of his laboratory. He was an indefatigable worker, his interests ranged from poetry to medicine, and he died as he had wanted to live: quietly and with a minimum of disturbance to his fellow man.

HANFORD TIFFANY
Northwestern University

ACADEMY BUSINESS

SECRETARY'S REPORT ON THE BUSINESS OF THE ILLINOIS STATE ACADEMY OF SCIENCE

For the Year May 4, 1946 to May 3, 1947

Compiled by HURST H. SHOEMAKER, *Secretary*

During the past year the Illinois State Academy of Science has had a rapid recovery from the adverse effects of the war. There was a record attendance of more than 700 persons at the annual meeting at which a large number of papers was presented. There were 112 papers presented in the nine regular sections and 31 in the two collegiate sections. The rapid growth of the collegiate section made the two sections necessary and suggests the need for more next year. At the annual banquet on May 2, Gustav A. Swanson spoke on Wildlife Research—Some Recent Advances. The committee on research grants reported $408.00 of the AAAS grant fund awarded as follows: To C. W. Bennett, Western Illinois State Teachers College, Macomb, $75 to make it possible to carry out work in microanalysis of 1-nitro-fluorine and 1-nitro-penanthrene. To W. M. Reid, Monmouth College, Monmouth, $75 for continuation of research on animal parasites. To H. F. Thut, Eastern Illinois State Teachers College, Charleston, $50 for research with hybrid ferns. To Sister M. Joan, College of St. Francis, Joliet, $83 for purchase of supplies for investigating possible chromatographic absorption in leafy vegetables. To P. E. Martin, Wheaton College, Wheaton, $125 to apply on purchase of equipment for continuing investigations of dynamic electrolysis.

Two committees were appointed to cooperate with Science Clubs of America in Science Talents Search program in awarding 21 college and university scholarships to high school seniors.

1. COUNCIL MEETINGS

Four council meetings were held during the year. The first one was held at Bloomington on May 4, 1946, with A. E. Emerson presiding. Possible meeting places for the next annual meeting were discussed but decision was postponed.

The second council meeting was held in Urbana, November 23, 1946, with L. R. Tehon presiding and seventeen in attendance. Reports were presented from the treasurer, secretary, editor, librarian, Junior Academy chairman, collegiate section coordinator, and committees on the Illinois Journal of Science, the research development project, and the State Museum building. Peoria was chosen as the place for the 1947 annual meeting and Dr. W. W. Grimm was elected second vice-president in charge of local arrangements. President Tehon outlined the responsibilities of the section chairmen. A resolution presenting the urgent need for a State Museum building was unanimously passed. It was decided to extend the Junior Academy of Science to include the grade school level. The Agriculture Section was discontinued as a result of the vote of this section on May 3, 1946; this section was merged with other sections, according with the major interests of the various members.

At the third council meeting, held at Urbana, January 25, 1947, reports from officers and committees were presented. The committee on the establishment of a proposed Illinois Journal of Science was discontinued, following the resignation of the chairman, for the following reasons: (1) The Academy is not financially able to back the venture; (2) the field of state science is too narrow to represent more than a portion ot the interests of the membership, and (3) all the good research now being performed in the state seems to have an adequate publication outlet. After discussion, a proposal to allow members to become life members after a certain number of years was dropped. Mrs. Audrey Hill Lindsey was introduced to the group as the new supervisor of the "Science on the Air" program.

At the fourth council meeting, held in Peoria, May 1, 1947, there were 23 pres-

ent. Vice-president Stover presided. The local arrangements committee with section chairmen and officers made final arrangements for the annual meeting. Reports were made by the AAAS delegate, the Junior Academy chairman, and the committees on conservation and living memorials. A motion was passed to learn the negotiable value of the real estate bonds owned by the Academy, to be reported at the next meeting. Plans for the establishment of an incorporated Academy foundation were discussed.

2. GENERAL BUSINESS MEETING

A short preliminary business meeting was held at 9:30 a.m., May 3, 1947, at which appointments were made to committees on nominations, resolutions and auditing. At the second business meeting held at 5:00 p.m., reports were heard from the treasurer and committees on auditing, resolutions, necrology, membership and science talent search. The Academy was invited to hold its next meeting in Harrisburg.

3. REPORTS OF THE TREASURER AND COMMITTEE ON AUDITING

(a) Report of Treasurer For the Year May 1, 1946 to April 30, 1947

Receipts

Balance on hand April 30, 1946		$ 1,602.79
Dues and initiation fees:		
Annual members	759.10	
Affiliated societies	1.00	
		760.10
Interest on Forbes and Meyer real estate		18.00
Interest from U. S. Savings bonds		5.00
Libraries		1.00
Research grant by the AAAS		75.00
Junior Academy:		
Dues	7.00	
Sustaining memberships	300.00	
		307.00
Total Receipts		$ 2,768.89

Expenditures

Council dinner	25.60
Speakers' expenses	50.00
Officers' expenses	10.00
Section Chairmen expenses	47.11
Postage, Treasurer's office	24.95
Expenses of Secretary's office	98.19
Corporation registration	1.00
Printing	340.75
Secretary, honorarium	100.00
Editor, honorarium	150.00
Research grant, W. M. Reid	75.00
Junior Academy	308.60
Total Expenditures	$ 1,231.20
Balance in the Commercial National Bank of Peoria	1,537.69
	$ 2,768.89

Statement of Resources, April 30, 1947

Balance in the Commercial Bank of Peoria	$ 1,537.69
Certificate of Interest for Meyer Block Leasehold	Value Unknown
Certificate of Interest for Forbes Building	Value Unknown
United States Savings Bonds, Series G	200.00
Total Resources	$ 1,737.69

The membership of the Academy consists of 60 life members, 92 new annual members, 18 sustaining members, 555 members paid up to and including the year 1947, 67 members one year in arrears, 39 members two years in arrears. The total membership is 831.

During the year 9 members have resigned, and 16 have removed, leaving no forwarding address.

(Signed) JOHN VOSS,
Treasurer.

(b) Report of the Committee on Auditing, May 1, 1947

To the Illinois State Academy of Science:

Your committee on auditing respectfully submits the following report:

We have examined the records of the Treasurer for the year May 1, 1946 to April 30, 1947, and find them correct. The present financial status of the Academy is as follows:

Cash on deposit with the Commercial National Bank of Peoria	$1,537.69
Series G., U. S. Savings bonds, two	200.00
Meyer Block Leasehold Certificate No. 15 (value unknown)	0.00
Forbes Building Certificate No. 13 (value unknown)	0.00
TOTAL ASSETS	$1,737.69

(Signed) L. P. Elliott, Chairman
W. W. Grimm

4. REPORT OF COMMITTEE ON SCIENCE TALENT SEARCH SCHOLARSHIPS

On March 8 a committee meeting was held in Urbana with Dr. Tehon and Dr. Shoemaker. It was decided to send a letter to the presidents of all colleges and universities in the state, outlining the plans for the State Talent Search and asking for scholarships from the various schools. The members of the committee were asked to help wherever possible in furthering the project. The letters to the college presidents were mailed on March 28. Because of the late start, the response was not as great as we had hoped for, because many schools had already made all of the scholarship commitments. However, scholarships were offered by the following schools: University of Chicago, Illinois College, Barat College of the Sacred Heart, Monmouth College, James Millikin University, Bradley University, MacMurray College, and Eureka College.

The committee on Science Talent Search selection awarded scholarships to fifteen students.

(Signed) Eliot C. Williams, Jr.,
Chairman

5. PUBLICATIONS COMMITTEE REPORT

The Publications Committee approved a plan whereby the authors' reprints from the Transactions would be ordered at the time the volume goes to press, the authors to purchase their reprints from the Academy at the following prices:

Copies	2pp.	4pp.	8pp.	12pp.	16pp.	24pp.	Covers
100	2.00	2.40	4.15	5.65	7.00	10.75	3.85
Additional 100's	1.00	1.40	2.20	2.95	3.30	5.20	1.40

6. REPORT OF THE COMMITTEE ON HIGH SCHOOL SCIENCE AND CLUBS

The committee recommended that the Junior Academy be extended to include grade school children, that the Senior Academy cooperate with the Science Clubs of America in a Science Talent Search program whereby promising high school students would be recommended for college scholarships, and that the teachers of student winners also be given certificates in recognition of their work. These were approved by the Senior Academy.

The committee adopted a simplified entry tag for use by student exhibitors.

A Science Field Day was held at Southern Illinois University, Carbondale, April 19, 1947. About 400 members representing 20 clubs attended the meeting, and displayed 148 exhibits.

About 400 students attended the annual May meeting at Peoria at which 175 exhibits were displayed. Awards were presented to winners after the banquet.

7. REPORT OF COMMITTEE ON RESOLUTIONS

Resolutions with Respect to the Final Disposition of Public Domain into Private Ownership

Resolution No. 1

WHEREAS, it has come to the attention of the Illinois State Academy of Science that a small group of private interests are campaigning to have vast areas of public land transferred to private ownership: and

WHEREAS, a joint committee of cattlemen and woolgrowers has organized at Salt Lake City to achieve this end: and

WHEREAS, the following statement by J. Elmer Brock, vice-chairman of this committee, was published in The Denver Post on February 2, 1947:

> "The duties of the committee shall be to propose legislation for the final disposition of the public domain into private ownership."

And

WHEREAS, Mr. Brock has further stated publicly (quoted by *Trail and Timberline*, March 1947):

> "Eventually stockmen hope to return other (than Taylor lands) public grazing lands in the west to private owners, the men who now utilize those properties. The total grazing lands include some tracts now in the national forests and even some tracts which never should have been included in the national parks but have been placed there."

Therefore,

BE IT RESOLVED, that the Illinois State Academy of Science in annual meeting assembled at Peoria on Friday, May 2, 1947, go on record as upholding the belief that, considering the future need for more land for recreational use and considering the fact that the resources of grazing range and timber in these areas are now being nationally administered to good advantage, it would not be for the greatest public interest to permit the return of any land now included in National Parks or Forests to private ownership; and that the Academy declare its opposition to any bill which confers on private interests monopolistic control of public lands or which provides for the transfer of National Park and Forest areas into private ownership: and

BE IT FURTHER RESOLVED, that our Secretary be and is hereby directed to send copies of this resolution to the President of the United States, the U. S. Secretary of Agriculture, and the U. S. Secretary of the Interior, members of the U. S. Senate and the House of Representatives from Illinois, and the Secretary of the American Association for the Advancement of Science, and that a copy of this resolution be entered in the Transactions of the Academy, and

BE IT FURTHER RESOLVED, that the Conservation Committee of the Illinois State Academy of Science be and is hereby directed to give this matter their continued attention and to take whatever further action they may deem advisable in support of this resolution.

Resolution No. 2.

WHEREAS, there has been some insistance that certain portions of the Olympic National Park in the State of Washington be returned to private ownership, for the benefit of commercial lumber interests, and

WHEREAS, certain bills have been introduced in Congress to effect these changes, and

WHEREAS, the National Park Service has recommended that some but not all of these tracts, totalling about 56,000 acres, be relinquished, generally for better administration and fire protection of the park, and

WHEREAS, there is also agitation to permit "selective" logging in the park, a procedure that would be contrary to the purpose of the park to preserve for the posterity of our country a relic of our original forest in its native condition,

BE IT RESOLVED, by the Illinois State Academy of Science in annual meeting assembled at Peoria on May 2, 1947, that in principle it is opposed to the release to private ownership of any land now in national parks and that with respect to the proposed release of certain tracts in the Olympic National Park, no more than that recommended by the National Park Service should be relinquished, and

BE IT FURTHER RESOLVED, that our Secretary be and is hereby directed to send copies of this resolution to the President of the United States, the U. S. Secretary of Commerce, the U. S. Secretary of the Interior, members of the U. S. Senate and the House of Representatives, and the Secretary of the American Association for the Advancement of Science, and that a copy of this resolution be entered in the Transactions of the Academy, and

BE IT FURTHER RESOLVED, that the Conservation Committee of the Illinois State Academy of Science be and is hereby directed to give this matter their continued attention and to take whatever further action they may deem advisable in support of this resolution.

Resolution No. 3

WHEREAS, the sum of $50,000 requested by the National Park Service and included in the U. S. Department of Interior appropriation bill for preliminary surveys of archeological and paleontological sites within the Bureau of Reclamation and the Corps of Engineers projects have been reduced by half by the Committee on Appropriations, and

WHEREAS, such preliminary surveys are necessary to insure study and salvage of data at important sites before they are flooded, and

WHEREAS, the Committee has also removed the provision whereby any funds appropriated to one agency may be transferred to another for administration, an action that would hamper, if not prevent, such preliminary surveys,

BE IT RESOLVED, by the Illinois State Academy of Science in annual meeting assembled at Peoria on May 2, 1947, that it is opposed to any provisions in the U. S. Department of Interior appropriations bill restricting transfer of funds from one agency to another where such transfer is conducive to more effective administration, and

BE IT FURTHER RESOLVED, that our Secretary be and is hereby directed to communicate by telegraph this opinion to the proper authorities.

Resolution No. 4

BE IT RESOLVED by the Illinois State Academy of Science in annual meeting assembled at Peoria on May 2, 1947, that the State of Illinois shall not relax its legal protection of predacious birds and that the goshawk, great horned owl, and birds predatory on fish be added to the list now afforded legal protection, and

BE IT FURTHER RESOLVED, that the proper representatives of our Academy be and are herewith directed to implement this resolution by whatever action may appear desirable and necessary.

Resolution No. 5

BE IT RESOLVED, by the Illinois State Academy of Science in annual meeting assembled at Peoria on May 2 and 3, 1947, that it extend its appreciation to Bradley University, to the Peoria Academy of Science, to the Peoria Association of Commerce, to Mr. W. W. Grimm, and to all of those who have assisted him in arrangements for this meeting, and to all other organizations and individuals who have in any way contributed to the success of this meeting.

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STATE OF ILLINOIS

DWIGHT H. GREEN, *Governor*

TRANSACTIONS

OF THE

ILLINOIS STATE ACADEMY OF SCIENCE

VOLUME 41 1948

Forty-First Annual Meeting

Benton, Illinois

May, 1948

PRINTED BY AUTHORITY OF THE STATE OF ILLINOIS

ILLINOIS STATE ACADEMY OF SCIENCE

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Contents

PAGE

MORNING ADDRESS

STOVER, ERNEST L., Mark Hopkins and the modern log 7

PROGRAM FOR THE 41st ANNUAL MEETING

Papers presented 13

ARCHAEOLOGY AND ANTHROPOLOGY

SCHOENBECK, E., Steuben Village site, a Hopewellian village of central Illinois.. 19

BOTANY

BAILEY, WILLIAM M., Some pioneers in natural history and biology in southern Illinois 23
BENEKE, E. S., The Monoblepharidaceae as represented in Illinois 27
HALL, JOHN W., The genus *Anemone* in Illinois 32
LORENZ, RALPH W., Thinning returns from an eastern white pine plantation in Ogle County 39
MYERS, R. MAURICE and WRIGHT, PAUL G., Initial report on the vegetation of McDonough County, Illinois 43

CHEMISTRY

BENNETT, C. W., The Dysonian system of organic notation 49
CORTELYOU, W. P., Quantized qualitative analysis 51
KLOSE, THEODORE G., A method for recalling the configurations of the aldohexoses 56

GEOGRAPHY

GARLAND, JOHN H., Occupance of the Moraine Border of northern Illinois 59

GEOLOGY

CADY, GILBERT H., Coal resources of Franklin County, Illinois 65
MCDURMITT, NANCY, Oil accumulation in the Cypress sandstone in the Herald pool, White and Gallatin counties, Illinois 77

PSYCHOLOGY AND EDUCATION

THOMANN, DON, Educational plans of Illinois high school students in relation to financial situation and academic aptitude 85

SOCIAL SCIENCE

GORDON, HAROLD, Administrative problems of township government in Du Page County 91

ZOOLOGY

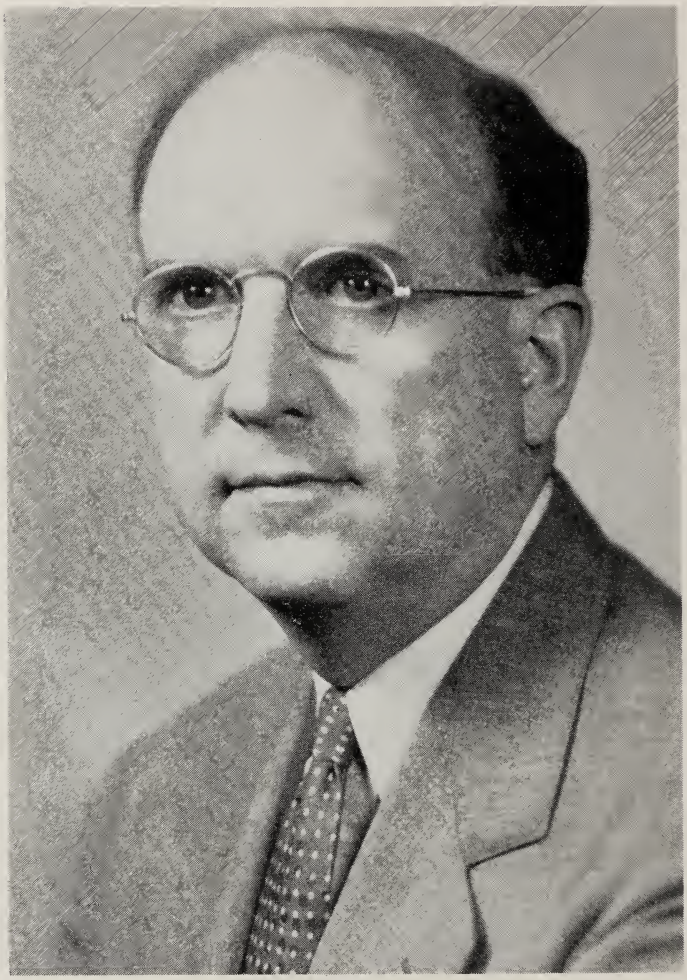
BALDUF, W. V., A summary of studies on the ambush bug, *Phymata Pennsylvanica Americana* Melin 101
DORRIS, TROY C., The zooplankton of Crab Orchard Lake during the first year, 1941-1942 107
MANUEL, HAROLD D., A mosquito survey of Lake Bloomington 111
RIEGEL, GARLAND T., Sex and the altitude of flight in Cyclocephala 113

MEMORIALS

CLARENCE BONNELL, by George D. Fuller 117
TERENCE THOMAS QUIRKE, by Harold R. Wanless 119
THOMAS EDMUND SAVAGE, by Harold R. Wanless 121
JOHN VOSS, by George D. Fuller 123
ISABEL S. SMITH, by George D. Fuller 124

ACADEMY BUSINESS

Secretary's report for the year 1947-1948 125



ERNEST L. STOVER, PRESIDENT, 1947-1948

PRESIDENTIAL ADDRESS

MARK HOPKINS AND THE MODERN LOG

ERNEST L. STOVER
Eastern Illinois State College, Charleston

President Garfield once said that his idea of a college was Mark Hopkins on one end of a log and a student on the other. I do not know all that President Garfield had in mind when he made this often quoted statement but the complement presents the picture of a superior teacher, a person of scholarship, able to inform, direct, and inspire his pupil. The personality of such a teacher is characterized by charm, by enthusiasm for learning, by intuitive and intelligent skill in dealing with human beings. His special ability is to use knowledge to create interest, to make the hard task seem easy, and to use his understanding of people to bring about advantageous changes in character. The personifications of this ideal have built schools, departments of learning, and whole professions. The testimonials of their efficiency lie among traceable groups of professional men and in valued memories of untraceable individuals. There are not many who have represented this ideal, but wherever they have lived their influence has acted as a permanent leaven in the lives they have t o u c h e d, strengthened ambitions, and raised standards of achievement. The sphere of their influence has been over the nation and into new generations of students, but the center of that influence has been in the laboratory and classroom.

According to a recent bulletin from Mt. Holyoke College, Mark Hopkins had a brother who was a chemist, and he needed more than a log; he needed a laboratory. With the great teachers of the sciences, these workshops were places where the teacher himself progressed in the pursuit of knowledge, and the students knew, by precept and example, the momentum of the search for new truth and enthusiasm in its discovery. Fortunately for many of us there have been teachers—of less fame than Mark Hopkins, Agassii, Jordon, and Bessey—who have exerted these same influences in colleges and secondary schools. We can look back and say of some important directive force in our lives that it was the work of such a teacher; and our gratitude has been as fervent as it was often late in recognition.

Is it not for these qualities of leadership in the world of thought that the professional training of teachers is aiming, especially in the fields of the sciences where the goal is to influence habits of thinking and where the laboratory provides the "log" for informal and direct leadership, the ideal that emphasizes an independent but personal relationship? The creative result of that relationship must be the accepted ideal of those interested professionally in improving science teaching. Much has been written about what science teachers do not know, what combinations of courses they are teaching, what the organization of the courses they teach should be, what their objectives should be, what adults read (or have a chance to read) in the daily papers, what the "practical aspects" of science are that may improve man's physical condition and

give the tax-payer value received for the money spent for the teaching of the sciences. In the literature of science teaching there is apparent approval of the unification of subject matter as the correct principle of organization through the entire school system. In all of these objective and subjective philosophies there is almost nothing that emphasizes the particular requisites of science as a distinctive method of learning with a distinctive educational value resulting from that method.

Not stopping to discuss personal qualities, or the manual and visual skills needed in handling materials for classroom studies, what are the tools of the teachers of the sciences? The questions said to be asked in order of their incidence as the mind develops are: what is it, how does it work, and why does it do it? What, how, why—these are the grist to the mill of teaching; and in exactly that order the teachers of the sciences need certain bodies of knowledge from the various divisions of each of the fundamental sciences.

To answer the question, "What is it?" in the biological sciences, the teacher must know the main groups of plants and of animals, the names of individual kinds, and the characteristics by which they are identified at a glance. He finds it advantageous to know how the names came to be given and something of interest about the specimen, and particularly how to find out these facts if he does not know them. To achieve the ability to answer this one kind of question, about plants alone, he must have studied the taxonomy and gross morphology of the main groups, he must have practiced the use of keys and field identification until by patience and effort he has gained some degree of speed and sureness, and also has some idea of the value and usability of this type of information. To comprehend the time-cost of such ability it must be remembered that ferns, flowers, woody plants, birds, insects, fish and other aquatic life, each have separate techniques and vocabularies.

The fact that no one knows all this range of information does not invalidate the necessity of a fund of learning to answer just this one kind of question. It is this kind of knowledge that enables a teacher to make a walk through a well-known field a revealing experience to his students. Is it because the recognition of plants, animals, and rocks by name, is a dull or "impractical" kind of knowledge that such teaching has been left to Scout organizations, National Park naturalists talking to tourists, and other vacation activities?

The answers to the questions "how" and "why" are more commonly thought of in connection with science training. To answer questions concerning stages of events and their causes in studies in the biological sciences, the teacher must know the activities of plants and animals in specific relation to the structures concerned, and the processes in relation to the anatomy taking part in each process. Any disjunction of process and place of occurence prevents the formation of clear mental concepts that are the basis of usable knowledge. "Why" questions are often answered correctly by "I do not know," which may be the only intelligent and honest answer, but too often the lack of an answer is disguised by just words that seem to be an answer to the thoughtless, as in saying that plants grow toward the light because they need light. To provide real answers for this type of question requires experimental experiences in the laboratory and in the field. Causes and results of natural phenomena can only be explained to students by discipline in

both the fundamental and applied sciences for all natural phenomena involve a series of physical, chemical, and physiological changes.

Among the thoughtful leaders of professional teaching there is no tendency to minimize the necessity for a large amount of factual knowledge for the teacher, but there are those who favor (without objective evidence as to value) the generalized type of course to such a degree that the result is to reduce the amount of factual learning below a desirable minimum. This tendency has been partly a result of just criticism of the old "type" course in which the facts learned often had no connection with the daily phenomena of living. One of my friends told me that students in one of our universities were half through a semester course in botany before they realized they were studying plants.

The tendency toward generalized courses has also resulted from the discernment of the interdependence of one branch of science on knowledge from another. But whatever the cause of this move toward generalized courses involving more than one field of science, it has resulted in a philosophy of man's-interest-the-center-of-v a l u e in education; and as it has over-reached legitimate aims it has in turn divorced science and science teaching and placed real obstacles, I believe, in the way of achieving superior teaching in the sciences.

Mark Hopkins could get along with a log and his brother needed a laboratory, but the modern Hopkins needs much more than these things connote to the average mind.

Of first importance is the training of the individual teacher. This not only includes his training in a science and the related sciences but his training in how to organize and present the material to his classes. We have criticised the teachers colleges and colleges of education very severely on their over-emphasis on method of presenting material to classes, and they in turn have criticized the college and university science teachers for their laxity in trying to improve their methods of teaching. It is unfortunate that the professors of education have had so much to say without enough factual information and it is equally unfortunate that the teachers of the sciences have for the most part continued as they were taught and have not consistently tried to improve their teaching. There is an increasing number of science teachers who are attempting to conduct research in their teaching rather than to continue to wishfully think they are doing a good job of teaching. If you wish to see how bad some of the science courses are, just ask for the final examinations to see how little some teachers expect the students to know at the end of a semester's or quarter's work. Research in teaching is equally important with research in isotopes and human physiology, provided the person conducting the research is well trained in the fundamental sciences.

We have criticized the survey or generalized courses that cover more than one field of science, and I believe justly so. The state high school visitors office has said that the poorest planned and poorest taught courses in the curriculum of our high schools are the so-called general science and biology as they are most commonly planned and taught. It is worthy of note that the University of Chicago and the Ohio State University both found that their students (in general botany at Ohio State and in the first year of biological science at the University of Chicago) who did the best work did not have biology in high school, and those who had biology in high school did less well. My colleague and I

found that the students who had courses in botany and zoology in high school were most likely to do well in college botany and college zoology, and that many of those who had the high school biology were low in achievement.

Another "sliver" that needs to be examined on the Hopkins log is the time honored plan of college courses that have lectures given by one teacher, the laboratory conducted by other teachers or graduate students who are more interested in an advanced degree than anything else, and a so-called quiz section often conducted by a third person. Students have long criticised science courses conducted in this lecture-laboratory-quiz plan, but the staffs of our colleges have for an equally long time ignored these criticisms. This is one of the places where, I believe, the professors of education have been justified in criticising the beginning science courses. There is accumulating evidence that the laboratory-discussion method of teaching a science is superior to any method yet devised. A number of colleges and universities are now working with this plan of presenting a science with much success. The laboratory-discussion method of teaching science begins with the laboratory as the source of information for the student, and has some aspects of real research for these beginning students. The textbook becomes a reference book and not the source of information. One teacher conducts the class throughout the term so that the students feel that the work is organized and presented in a definite sequence that is conducive to learning. This is commonly lacking in the lecture-laboratory-quiz method if the statements of several generations of students are to be believed.

Another sliver that almost amounts to a plank on the Hopkins log is the teaching load and overload of the high school teachers who are sending their students to us in the colleges. A study made by E. F. Potthoff of the University of Illinois has shown that in this state "3,490 teachers were teaching a total of 716 different teaching combinations of subjects. The average number of teachers per combination therefore was slightly less than 5, . . . and 96 per cent were taught by not more than twenty teachers. . . . More than three-fourths of the total number of combinations consisted of three or more subjects. The general picture presented by these results is that conditions with respect to subject combinations are chaotic." This is not peculiar to Illinois.

This situation can be corrected, and the responsibility in Illinois rests with the Office of the State Superintendent of Public Instruction and the College of Education and the office of the High School Inspector of the University of Illinois. The State Teachers Colleges have to date been followers and not leaders in maintaining the accrediting standards for our high schools. The bulletin of the University of Illinois entitled "The Recognition and Accrediting of Illinois Secondary Schools" was compiled by the University and the Office of the State Superintendent of Public Instruction in 1940. This was a real improvement over the previous standards but it has not been rewritten since that time.

There are criteria given for the minimum, medium, and superior preparation of teachers in all subjects. The minimum preparation for teaching botany or zoology is 8 semester hours. But if biology is taught the teacher only needs 5 hours of botany and 5 hours of zoology and 6 semester hours in some other courses in the biological sciences. In other words the high

school teacher needs less preparation in subject matter to teach a course of study that includes all of the biological sciences than to teach any division of the sciences in that group.

The physical sciences are evidently more difficult than the biological sciences, for according to the 1940 bulletin to teach chemistry or physics the teacher must have 10 semester hours in each and should have a minor in mathematics. If astronomy is taught in the high school that is not so difficult for only 5 hours of college preparation is required if the teacher has 16 semester hours credit in the physical sciences.

General science is expected to include physics, chemistry, botany, zoology, physiology, physiography or geology and astronomy and lately meteorology but the teacher can teach general science if he has to his credit 6 to 10 semester hours in the biological sciences and 6 to 10 semester hours in the physical sciences. It apparently makes little difference as to what courses are included.

But to teach speech in Illinois high schools the teacher must have 16 hours of college credit in courses in speech, exclusive of the required courses in oral and written English that are a part of the first year's work in college.

Since our high schools have 716 different teaching combinations and since the minimum accrediting standards for science teacher preparation in this state are so low, is it any wonder that many of our college and university graduates try to qualify for certificates in as many teaching combinations as possible? As a result they are often well prepared in only one subject and sometimes not well prepared to do superior teaching in that subject.

One remedy for the poor teaching that exists in our public schools is to simplify teaching combinations, to increase accrediting standards for teacher preparation, and to give the teachers time for preparation of laboratory materials so necessary for good science teaching.

The Illinois State Academy of Science through the committee on the Teaching of the Sciences has recommended to the Office of the State Superintendent of Public Instruction and to the Office of the High School Visitor of the University of Illinois that the following criteria be made a part of the accrediting standards for the teachers in the schools of Illinois.

1. We have recommended that no teacher of any subject be permitted to teach without a minimum of 16 semester hours in that subject, and that if combination subjects be permitted the teacher must have 16 semester hours in each subject of the combination. For example if physical science is taught the teacher must have 16 semester hours work in chemistry and the same in physics; if biology is taught as a combination course the teacher must have 16 semester hours of botany and 16 semester hours of zoology. It is of course expected that the hours of credit must be in courses of study that can furnish the material for high school classes.

2. If general science continues to be permitted it is recommended that the teacher must have a year's work in at least three of the subjects included in general science as it is now taught and a minor (16 semester hours) in one of the three. Personally, I believe general science should be dropped from high school curricula.

It is obvious that the log of Mark Hopkins is no longer adequate for the equipment necessary for the work of either college or high school, at least in the sciences. The teacher and his preparation is of first im-

portance, the plan or method of teaching and the laboratory equipment are probably equally important if our students are to have a square deal.

If the colleges and universities can obtain objective evidence and use that as well as the best subjective evidence for the training of science teachers, the work in our high schools will improve and as a result we will have better trained students than we now have in our first year college classes. To arrive at this improvement we as college teachers must obtain satisfactory objective evidence that our college courses are well planned and well administered.

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PROGRAM FOR THE 41st ANNUAL MEETING
PAPERS PRESENTED

ARCHAEOLOGY AND ANTHROPOLOGY

IRVIN PEITHMAN, *Chairman*
Carbondale

1. Review of Archaeological Societies and Journals in the United States; C.C. Burford, Urbana.
2. Dust, Bones, and Rocks: C. Joe Thomas, Cobden.
* 3. Steuben Village Site, A Hopewellian Village of Central Illinois; Ethel Schoenbeck, Peoria.
4. The Southern Death Cult in Illinois: Bruce W. Merwin, Southern Illinois University, Carbondale.
5. The Case of the Unknown Boy: J. C. McGregor, Illinois State Museum, Springfield.
6. Northeastern Influences in Maple Mills Culture: Donald Wray, University of Illinois, Urbana.

BOTANY

B. W. WELCH, *Chairman*
Southern Illinois University, Carbondale

SECTION A

1. Prairie Flora in Kodachrome: Theodore M. Sperry, Kansas State Teachers College, Pittsburg, Kansas.
2. Study of the Deciduous Forest at Funk's Grove, Illinois: Howard R. Clark, Lewistown.
* 3. Initial Report on the Vegetation of McDonough County: R. Maurice Myers, Macomb and Paul G. Wright, Carthage.
4. A Taxonomic Study of the Vascular Plants of Richland County, Illinois: Vera L. Scherer, University of Illinois, Urbana.
5. The Genera of Clavarioid Fungi to be Expected in Illinois: Maxwell S. Doty, Northwestern University, Evanston.
6. University of Illinois Herbarium: Edna L. Meadows, University of Illinois, Urbana.
* 7. Pioneers in Natural History and Biology in Southern Illinois: Wm. M. Bailey, Southern Illinois University, Carbondale.
* 8. The Monob'epharidaceae as Represented in Illinois: E. S. Beneke, University of Illinois, Urbana.
9. Notes on Myxomycetes from Illinois: Richard K. Benjamin, University of Illinois, Urbana.
10. A New Aquatic Pythium: Adrian W. Poitras, University of Illinois, Urbana.
11. A Check List of the Vascular Plants of Winnebago County: George D. Fuller. Illinois State Museum, Springfield, and University of Chicago. Read by title.
12. The Milk Weeds of Illinois: Grace Loescher Eyster, University of Illinois, Urbana. Read by title.

* Published in this volume.

SECTION B

1. Recurrent Ear-shoot Proliferation in *Zea mays*: O. J. Eigsti, Northwestern University, Evanston.
2. Morphology of Winged Pollen Grains of Pennsylvanian Age: R. M. Kosanke, State Geological Survey, Urbana.
3. A Study of the Anatomical Structures of the Stem of *Cunila origanoides* as it forms "Frost Flowers": Amy Mae Jones, Southern Illinois University, Carbondale.
4. Resting Root Primodia in Willows: Margery C. Carlson, Northwestern University, Evanston.
5. Photosynthesis in Relation to Stomatal Frequency and Distribution: Ralph O. Freeland, Northwestern University, Evanston.
* 6. Thinning Returns from an Eastern White Pine Plantation in Ogle County: Ralph W. Lorenz, University of Illinois, Urbana.
7. Preliminary Report on the Use of Brilliant Cresyl Blue as a Stain for Plant Chromosomes: Wilson N. Stewart, University of Illinois, Urbana.
* 8. The Genus Anemone in Illinois: John W. Hall, University of Illinois, Urbana.
9. Secondary Succession in Relation to Depth of Burning in a Michigan Peat Bog: M. E. Britton and Jane W. Roller, Northwestern University, Evanston.
10. Seasonal Variations in Soil Temperature at Evanston, Illinois: M. E. Britton, Northwestern University, Evanston.

CHEMISTRY

SISTER MARY MARTINETTE, *Chairman*
Mundelein College, Chicago

1. X-rays in the Art Galleries: G. L. Clark, University of Illinois, Urbana.
* 2. Quantized Qualitative Analysis: W. P. Cortelyou, Roosevelt College, Chicago.
3. Chemistry for Home Economics Students: R. A. Scott, Southern Illinois University, Carbondale.
4. The Oxidation of Alpha Methyl Glucoside: Mrs. Rosalie Leutgoeb, Mundelein College, Chicago.
5. Grignard Potentials: W. V. Evans and F. Cassaretto, Loyola University, Chicago.
6. New Frontiers of Fluorspar in the Chemical Industry: G. C. Finger, Illinois State Geological Survey, Urbana.
7. Technical Editing as a Career for Bachelors of Science: Mrs. Ethaline Cortelyou, Armor Research Foundation of Illinois Institute of Technology, Chicago.
* 8. The Dysonian System of Organic Notation: C. W. Bennett, Western Illinois State Teachers College, Macomb.
9. Detection of DDT in Corn Residues: Mrs. Joan Sandberg, University of Illinois, Urbana.
*10. A Method for Recalling the Configurations of the Aldohexoses: T. G. Klose, Loyola University, Chicago.
11. Proof of Structure in Organic Chemistry: J. V. Karabinos, St. Procopius College, Lisle.
12. An Elementary Introduction to Analytical Chemistry: J. Lester Dalton, University of Illinois, Galesburg Division.
13. Chemical Factors Influencing the Growth of Tubercle Bacilli; Development of Resistance to Sulfone Drugs and Antibiotics: Ben C. Sher, Municipal Tuberculosis Sanatarium, Chicago.
14. Industrial Electroplating: E. H. Hadley, Southern Illinois University, Carbondale.
15. Modern Oil Refining: Gustav Egloff, Universal Oil Products Company, Chicago.

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GEOGRAPHY

JOHN L. PAGE, *Chairman*
University of Illinois, Urbana

1. Gainesville, Florida—Core of a Unique Geographic Region: J. Edwin Becht, University of Illinois, Urbana.
2. Some Geographical Aspects of the Electrical Revolution: W. O. Blanchard, University of Illinois, Urbana.
3. Mexico's Proposed T.V.A.: Dorotha Garrison, University of Illinois, Urbana.
4. A Square Mile of Normandy—Aerial Photographs for Regional Studies: Elton M. Scott, Eastern Illinois State College, Charleston.
5. Agricultural Land Use in Iowa: Helen L. Smith, Wheaton College, Wheaton.
6. Illinois Railroad Geography: Alfred W. Booth, University of Illinois, Urbana.
7. Cairo's Manufactural and Shipping Activities: J. Herbert Burgy, Bradley University, Peoria.
* 8. Occupance of the Moraine Border of Northern Illinois: John H. Garland, University of Illinois, Urbana.
9. An Undiscovered Playground of Illinois: Mary Grant, University of Illinois, Urbana.
10. The Pottery Industry of Greene County, Illinois: John F. Lounsbury, University of Illinois, Urbana.
11. Geographic Limits of the Illinois Portion of the St. Louis Fluid Milk Region: Elizabeth D. Strasser, University of Illinois, Urbana.

GEOLOGY

LELAND HORBERG, *Chairman*
University of Chicago, Chicago

1. Study of the Structural Development of the Upper Horse Creek Area, Teton County, Wyoming: Virgil J. Kennedy, B. Walden Lynch, Howard L. Patton, Lindell H. Van Dyke, University of Illinois, Urbana.
2. The Spheroidal Weathering Cycle and its Possible Use in Interpreting Events in a Granite Area in Iron County, Missouri: Percival Robertson, The Principia College, Elsah.
3. Caliche in Southeastern New Mexico: Leland Horberg, University of Chicago, Chicago.
4. Geology and Limnology: Jack L. Hough, University of Illinois, Urbana.
5. Lineation of Stream Patterns in Illinois and its Interpretation: Max C. Firebaugh, University of Illinois, Urbana.
6. Silurian Rocks in the Vicinity of Naperville, Illinois: C. L. Bieber, DePauw University, Greencastle, Indiana.
7. Everything but the Contours: Margaret A. Parker, Illinois State Geological Survey, Urbana.
* 8. Oil Accumulation in the Cypress Sandstone in the Herald Pool, White County, Illinois: Nancy McDurmitt, Illinois State Geological Survey, Urbana.
* 9. Coal Resources of Franklin County: Gilbert H. Cady, Illinois State Geological Survey, Urbana.
10. Coal Resources of White County: John A. Harrison, Illinois State Geological Survey, Urbana.

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PHYSICS

GLEN W. WARNER, *Chairman*
Wilson Junior College, Chicago

1. Electron Triplets: P. G. Kruger and J. A. Phillips, University of Illinois, Urbana.
2. The Physics Teacher and Wartime Training Methods: Chalmer N. Patterson, Bradley University, Peoria.
3. A Quantitative Experiment with a Gyroscope: Philip A. Constantinides, Wilson Branch, Chicago City College, Chicago.
4. High Speed Automatic Computers: Arnold Nordsieck, University of Illinois, Urbana.
5. The Proposed I.A.S. Sponsored Research Foundation: Otis B. Young, Southern Illinois University, Carbondale.
6. Rectifiers and Multipliers for Use in AC-DC Voltmeters: Glenn Q. Lefler and Ora L. Railsback, Eastern Illinois State College, Charleston.
7. Evidence about Neutrinos: C. W. Sherwin, University of Illinois, Urbana.
8. Preliminary Survey of Water Currents in the Bosphorus: Roscoe E. Harris, University of Illinois, Navy Pier, Chicago.
9. Research in the Teaching of Physics: H. Clyde Krenerick, Milwaukee, Wisconsin.

PSYCHOLOGY AND EDUCATION

D. M. HALL, *Chairman*
University of Illinois, Urbana

1. Conceptions of Democratic School Administration, 1920-1946: Ogden H. Glasow, Western Illinois State College, Macomb. Read by title.
*2. Education Plans of High School Students in Relation to Financial Situation and Academic Aptitude: Don Thomann, High School Testing Bureau, University of Illinois, Urbana.
3. Job Satisfaction in Chicago: Willard A. Kerr, Illinois Institute of Technology, Chicago. Read by title.
4. Speech-Thought Relationship: Richard G. Songer, James Millikin University, Decatur.
5. Behavior and the Formative Mode: Gertrude Hendrix, Eastern Illinois State College, Charleston.
6. Measures of Visual Ability as Related to Believed Acuity: George L. Knedlik, Illinois Institute of Technology, Chicago. Read by title.
7. An Empirical Study of the Validity of Non-Assumption Statistics in Skewed Psychological Data with Evaluation of a New Measure of Variability, the Tripartile Deviation: Willard A. Kerr and Melvin Rudolph, Illinois Institute of Technology, Chicago.
8. A Program for Science Teacher Training: Arnold J. Hoffman, Eastern Illinois State College, Charleston.

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SOCIAL SCIENCE

LYNFORD A. LARDNER, *Chairman*
Northwestern University, Evanston

1. Physiocratic Doctrine in Ancient China: Lewis A. Maverick, Southern Illinois University, Carbondale.
2. A New Orientation in the Social Sciences: S. R. Kamm, Wheaton College, Wheaton.
3. Heart Disease—Its Impact on our National Life: C. C. Burford, Urbana.
* 4. Administrative Problems of Township Government in DuPage County: Harold Gordon, Wheaton College, Wheaton.
5. Historical Rhythm in American Foreign Policy: Frank L. Klingberg, Southern Illinois University, Carbondale.
6. Patterns of Rural-Urban Voting in Illinois: R. G. Browne, Illinois State Normal, Normal.

ZOOLOGY

WALTER M. SCRUGGS, *Chairman*
Eastern Illinois State College, Charleston

1. A Summary of Bionomic Studies on the Ambush Bug: Walter V. Balduf, University of Illinois, Urbana.
2. Changing Fish Populations as an Index to Pollution and Soil Erosion: John D. Black, Eastern Illinois State College, Charleston.
3. Oviposition and Egg Hatching in a Delpliacid, *Megamelus davisi*: C. S. Spooner, Eastern Illinois State College, Charleston.
4. Parasites of the Ranidae (Amphibia) VII: A. C. Walton, Knox College, Galesburg.
5. Distribution of Fishes in the Middle Fork River: Arthur O. Fleshsig, University of Illinois, Urbana.
6. Geographic Variation in the Penetrance and Expressivity of the Mutation "Notched" in *Drosophila macrospina*: Sidney Mittler, Illinois Institute of Technology.
* 7. Zooplankton of Craborchard Lake during the First Year, 1941-1942: Troy C. Dorris, Quincy College, Quincy.
8. Color Reactions with Malignant Tumors: Emil Weiss, Peoples Hospital Chicago.
9. Situs Inversus Viscerum in Cat and Man: James M. Sanders, University of Missouri, and Muriel Beuschlein, Chicago Teachers College, Chicago.
10. Effect of d-Amphetamine on Gastric Hunger Contractions and Food Intake in the Dog: William Sangster, M. I. Grossman, and A. C. Ivy, Loyola University and University of Illinois College of Medicine, Chicago.
*11. Sex and the Altitude of Flight in *Cyclocephala* (Coleoptera: Scarabaeidae): Garland T. Riegel, University of Illinois, Urbana.
12. An Anomalous Gall Bladder of the Domestic Cat: Albert G. Smith and William Sangster, Loyola University, Chicago.
*13. A Mosquito Survey of Lake Bloomington, McLean County, Illinois: Harold L. Manuel, Illinois State Normal University, Normal.
14. Comparative Weights of Normal and Hypophysectomized Chick Embryos with Reciprocal Grafts of Thyroid Glands: Florence M. Foote and Charles L. Foote, Southern Illinois University, Carbondale.
15. Some Unknowns in Wildlife Management and Research: Willet N. Wandell and Harlow B. Mills, State Natural History Survey, Urbana.

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ARCHAEOLOGY AND ANTHROPOLOGY

STEUBEN VILLAGE SITE, A HOPEWELLIAN VILLAGE OF CENTRAL ILLINOIS

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Peoria Academy of Science, Peoria

The Steuben Village site is reported here as known from explorations and collections made by the George Schoenbecks, members of the Peoria Academy of Science, since 1939 during which time about fifty collecting trips were recorded.

The site, listed as site 22 of the Peoria Academy of Science Survey and recorded also among the sites of the state in the Illinois State Museum Survey, is located on the west bank of the Illinois River about three miles north of Chillicothe, in Marshall County, Steuben township, section 34, T. 12 N, R. 9 E. It is a flat gravelly area of about five acres, lying between the river and the bluff. The C. R. I. & P. railroad and route 29 cut through its west side and a small creek runs through the south end.

There are eight mounds on the bluff, one of them about 114 feet long, but it is not known whether or not these belong to the village.

Material is known from the plowed surfaces of several slight ridges, from post-holes and shallow excavations, and from a lower level exposed in the bed and banks of the creek. The buried occupation level lay immediately under a layer of gravel several inches thick, and at one place was 7 feet below the present surface.

Photograph by E. Schoenbeck.

FIG. 1.—The largest of the eight mounds on the bluff above Steuben village site measures about 84 by 114 feet. It has not yet been determined whether or not these mounds belong to the village.

Much excellent material is said to have been obtained by earlier collectors.

Material collected is Hopewellian, with the exception of a small amount of cord-decorated pottery, and includes chert items, bone refuse and bone tools, stone items, mica, red ochre, shell articles and refuse, and pottery.

Items of particular interest are the stone human head effigy[1] and a pink chert bird effigy. Another bird effigy is in the Leroy P. Elliott collection. Conspicuous in the chert artifacts are the large number of medium-sized notched points and narrow flake knives. Of interest in the pottery is the 3 to 1 proportion of punctate to dentate stamp, with both decorations of the simplest types, and some red-painted and thickened-rim ware.

About 950 rims and some thousands of body sherds are in the pottery collections. Types included are Woodland plain (or smoothed); Woodland cord-roughened; Sister Creeks punctated; Naples dentate stamped; fine limestone-tempered Hopewell with cross-hatched incised and rocker-stamped rims; red-painted thickened-rim ware from the lower Mississippi Valley; incised; brushed; bar-stamped; Clear Lake cord-wrapped-paddle-edge stamped; and Maple Mills or Gooden cord-decorated.

A light colored wash shows on some of the sherds and there are two examples of the bored hole in the vessel wall.

The punctated sherds include 525 rims and 66 lower rims; 73 are punctated on the lip; 8 bear disk or circle punctates. All others are simple two to three punctates in arrangements on the rim.

The dentate-stamped sherds include 157 rims and 83 lower rims. Only 8 have any but the simplest stamp, placed vertically and singly without elaboration.

There are 103 Woodland cord-roughened and 68 Woodland plain; 13 others are bossed. The cord-wrapped-paddle-edge stamped include 10 rims, some thin, others heavier. The cord-decorated includes one lower rim of the usual decoration and 17 body sherds; there is also a rim showing cord punctates on a plain surface. A collared rim may or may not be of this type.

The finer Hopewell and imitations have 31 cross-hatched incised rims, rocker stamp, etc. There are three red-painted and three of the thickened rim, one of which is red filmed and one of which bears incised designs on the wide rim. There are 50 rocked or zoned, limestone-tempered or leached body sherds and one portion of lobed body.

A part of the "brushed" ware is limestone tempered.

Chert items number in the hundreds, and considering the other known and reported collectors, must have been very abundant. Points, knives, scrapers and spuds are the principal items. Points, many of them crude, are mostly notched, some are stemmed and some are lanceolate, and they total about 500. Flake knives are plentiful. Scrapers are of several types. The bird effigy is two inches long.

Collections made in earlier years must have contained many fine pieces because the casual collector generally picks up only perfect items and chert was so plentiful on the site. Large specimens of the fine Hopewellian blades are among items reported.

Bone tools comprise only four awls and one cut antler, but refuse animal bones and teeth are present

[1] Described in 1947 Transactions, Illinois State Academy of Science under title, "A Seven-pound Copper Axe Among 1946 Hopewell Discoveries."

in some quantity. Many are rotten and deteriorate quickly. Fish otoliths are numerous.

Two shell hoes are among the shell remains; each shows the round hole in the center.

The stone material includes portions of 15 pendants; all seem to be oblong, none are reel-shaped. Other items are many pitted hammer stones; a few celts and axe portions; ball-shaped chert pecking stones; a few shaped disks and several grooved mauls.

The finely executed sandstone human head effigy, reported in 1947 *Transactions,* has since been compared closely with one found at the Twenhafel site in Jackson County of southern Illinois and it was the unanimous opinion of Thorne Deuel, Director of the Illinois State Museum, George K. Neumann of Indiana University, and Mr. and Mrs. George Schoenbeck, that the two heads might have been made by the same hand. The Twenhafel head differs by having a headdress, but both have the same highly stylized ear and show similar workmanship. James B. Griffin, Curator of the Ceramic Repository, University of Michigan, states that a similar one has been found in Oklahoma.

A brief comparison of the Steuben material with that from the Hopewellian Clear Lake village might be of interest here. The Steuben site has much more chert and more pendants. Few bone tools have been found at Steuben, but collecting mostly from the surface rather than from excavations must be taken into consideration.

A comparison of pottery brings out the predominance of punctate over dentate stamped at Steuben and the reverse at Clear Lake; a scarcity of cord-wrapped-paddle-edge at Steuben and an abundance at Clear Lake; a complete lack of the black sands incised ware and a mere representation of the cord-decorated at Steuben, while Clear Lake has a good showing of the first and the largest amount of cord - decorated ware known from any Illinois site. Steuben dentate-stamp lacks the elaborated arrangements and variations and shows no bossing, whereas Clear Lake has an abundance of such. The heavy crushed rock or Fayette thick ware is lacking at Steuben but is also rare at Clear Lake.

Neither site had a Mississippian occupation; Clear Lake had but a few sherds of Mississippian pottery and Steuben had none.

BOTANY

SOME PIONEERS IN NATURAL HISTORY AND BIOLOGY IN SOUTHERN ILLINOIS

WILLIAM M. BAILEY
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Cyrus Thomas

When the Southern Illinois Normal University opened its doors to students in 1874, there was on the faculty a biologist and naturalist of national reputation, Cyrus Thomas, who became one of the foremost early systematic and economic entomologists.

Cyrus Thomas was born July 27, 1825, at Kingsport, Tennessee. He attended the schools of his native state. As a young man he began the study of law. He moved to Illinois in 1849. For a short time after coming to Illinois he was engaged in teaching school. Later he was appointed deputy county clerk in the office of John A. Logan, who was county clerk of Jackson County.

In 1851 Thomas was elected county clerk of Jackson County. About this time he was admitted to the bar. He held the office of county clerk for one term, and at the expiration of his term of office he began the practice of law at Murphysboro. While engaged in the practice of law he also applied himself to the study of natural history.

In 1864, upon the death of his wife, who was a sister of John A. Logan, he abandoned law, and entered the ministry of the Lutheran Church, a profession for which he had been quietly making preparation.

During the period from 1869 to 1873 Thomas served as entomologist and botanist on the United States Geological and Geographical Survey of the Territories, under Ferdinand V. Hayden. Thomas's reports, published with the reports of the expedition, constituted an important feature of these publications.

In 1874 Cyrus Thomas was appointed a member of the faculty of the Southern Illinois Normal University, beginning his work in this institution at the opening of the fall term that year. His salary, $1800 per year, was the highest paid to any member of the faculty except the president, then called the principal. He was listed as teacher of natural history and physiology, and later as also curator of the museum.

In 1875 Thomas was appointed State Entomologist of Illinois. He was then able to devote only a part of his time to the work in the Southern Illinois State Normal University.

During the period from 1874 to 1876 vast areas of the plain west of the Mississippi River were devastated by the Rocky Mountain locust, or grasshopper. In order to meet this problem, Congress provided for the appointment of the United States Entomological Commission, of which Charles V. Riley was made Chairman, and Cyrus Thomas and A. S. Packard, Jr. were appointed the other members. Thomas was made treasurer of the commission. He had made a special study of the Acrididae (true locusts, or grasshoppers), had been connected with the United States Geological Survey as an en-

tomologist from 1869 to 1873, and was State Entomologist of Illinois. His work on the Commission necessitated the severance of his connection with the Southern Illinois Normal University. The work of the Commission was begun in 1877 and completed in 1882. It constituted an important step in the development of economic entomology in the United States.

After the completion of the work of the United States Entomological Commission, Cyrus Thomas devoted the remaining twenty five years of his life to work in archaeology and ethnology with the Bureau of American Ethnology, under the Smithsonian Institute. He became a recognized authority on the Cherokee and Shawnee Indians, and the Maya inscriptions and codices. He remained active in the later years of his life. When he was eighty-four years of age, it was said that he was mentally as active as ever. He died June 27, 1910, at the age of eighty-four years and eleven months.

Thomas published his first paper in 1859, in the *Prairie Farmer*, on the chinch bug. He continued to publish articles on entomological subjects in the *Prairie Farmer* and the *Illinois Farmer* for a number of years. In the *Transactions of the Illinois Horticultural Society* for 1877-78 he published a rather long article covering a number of injurious insects. His third report as State Entomologist, published in 1879, contained the first comprehensive taxonomic study of the homopterous family Aphididae (Aphids) published in America. His most important paper was the synopsis of the Acrididae (true locusts, or grasshoppers) of North America, published in 1873. He named many new species in the Acrididae and the Aphididae.

George Hazen French

George Hazen French was born in central New York March 19, 1841. He attended the rural schools of his native region. In the fall of 1859 or 1860 he entered Cortland Academy as a student. He attended this academy two terms. This was the only schooling he had above the common rural schools of that time. In the botany class in the academy he did his first work in the identification of plants. He evidently showed unusual interest and ability in this work, as he received from Professor Woods, author of the textbook used, an invitation to go with him on a collecting trip in the west.

French began teaching in the rural schools of central New York, in the fall of 1861. His salary was $1.75 per week or $7.00 per month and board. He got the board by "boarding around" among the patrons of the school. This was the custom in the district schools at that time. French wrote in the notes on his life experiences that the salary was not exceptionally low. He continued to teach in the rural schools of central New York for several years.

He then came west to Illinois and taught in the schools of this state. In 1868 he passed the state examination given by Newton Bateman, State Superintendent of Illinois, and received a state certificate.

In the fall of 1868 French accepted a position as science teacher in the Illinois Agricultural College, Irvington. He stated in his notes that he "had never seen the inside of a college." He had studied chemistry and other sciences while teaching. He continued to teach sciences in the college at Irvington for nine years.

One of the things that had an important influence on the later work

of French was his meeting with George W. Vasey, a botanist, who had made a collecting trip in the west under government patronage. He taught French how to mount plants in the proper way. The latter began vigorously to carry on the work of collecting plants and making exchanges with other botanists. He discovered a new species of shooting star (Dodecatheon) in this region, which Vasey named in his honor *Dodecatheon Frenchii.*

French studied Greek with the daughter of the president of the college at Irvington. He had also learned some French. The college began publishing B. Sc. after his name, and at the commencement in 1874 conferred the A.M. degree upon him.

When in 1877 Cyrus Thomas was appointed a member of the United States Entomological Commission, French became his assistant. In August of 1877 French moved to Carbondale where he served as Assistant State Entomologist, working in the museum of the Southern Illinois Normal University. On July 1, 1878 he became a member of the faculty of this institution, as instructor in natural sciences, and curator of the museum. His subjects were zoology, botany, and physiology. He held this position for thirty-six years. He continued his work as Assistant State Entomologist for about two years after coming to Carbondale.

Soon after moving to Carbondale, French began writing for the scientific press. He wrote and published a manual on the butterflies of this region which passed through three editions. He also wrote a manual on the mushrooms of the region.

On the afternoon of November 23, 1883, the building of Southern Illinois Normal University was destroyed by fire and the museum was destroyed with it. Only the herbarium and a few cases of insects were saved. In the years that followed, French built up another museum, better than the one that had been destroyed. Most of the specimens and collections were the results of his own work.

French became widely known for his entomological work. He was a member of the A.A.A.S., the Illinois State Academy of Science, the Entomological Society of France, the Entomological Society of Belgium, and other scientific organizations. His life came to a close January 2, 1935, when he was ninety-three years old.

John P. Gilbert

Professor John P. Gilbert was the first biologist on the faculty of the Southern Illinois Normal University with university training.

John Philo Gilbert was a native son of Southern Illinois. He was born on a farm in Jefferson County July 27, 1872. His early education was secured in the country schools. He was bereft of the care and help of his parents early in life, as the death of his mother occurred when he was seven years of age and that of his father when he was sixteen. Thus he was left to plan his own career with the assistance of the older children of the family.

He began his educational career as a country school teacher. He entered the Southern Illinois Normal University as a student in 1892. After four years of active school life in this institution, during which he became prominent in debate and oratory, he graduated in 1896. After his graduation he advanced rapidly in the teaching profession, holding such responsible positions as the principalship of the high schools of Olney and Mattoon, and the superintendency of the schools of Tuscola.

In 1903 Mr. Gilbert entered the University of Illinois. Here he pursued his biological studies and also taught biology in the academy of the University. At the University he received the bachelor's degree in 1905 and the master's degree in 1906. He won high honors as a member of a debating team that won an intercollegiate debate between the University of Illinois and the University of Indiana. In the University of Illinois he was elected to the honorary scientific fraternity Sigma Xi.

In 1911 Gilbert became head of the Department of Biology of the Southern Illinois Normal University. This position he filled with conspicuous success. In 1920 he was given a leave of absence beginning September 1, in order that he might serve as secretary of the Southern Illinois Development Association. Within a year his health, which was already impaired, failed completely, and on April 10, 1921, the hand of death cut short his useful life in the 49th year of his age.

For some time Gilbert was active in chautauqua work, carrying the messages of nature study to children and adults. Upon the decline in the work in the chautauquas, he participated actively in the work of the State Farmers' Institute of Illinois. He was a man of wide and varied interests. The State Dairy Association, State Poultry Association, and the horticultural interests of Southern Illinois received his active support. He was active in church, lodge, and other worthy community enterprises. Gilbert's energy and ambition, his intellectual ability, his abounding optimism and his ability as a public speaker made him a strong factor in the advancement of Southern Illinois.

In this paper we have considered the work of a very few among many pioneers. May we remember with appreciation the work that the pioneers did, often under great handicaps, and the foundations that they laid.

THE MONOBLEPHARIDACEAE AS REPRESENTED IN ILLINOIS*

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The Monoblepharidaceae form a small family of aquatic fungi containing three genera, *Monoblepharis*, *Monoblepharella*, and *Gonapodya*, with a total of about 13 species. Interest in this family developed when Cornu published his description of *Monoblepharis* in 1871. Thaxter (1895) was the second person to find these organisms, reporting species from the United States in 1895. The genus *Gonapodya* was described by Fischer (1892), and recently the genus *Monoblepharella* was established by Sparrow (1940). Four of the thirteen species are known to occur only in tropical or subtropical regions, while the others have been found in the temperate climates. This family is of special interest to students of mycology in that it is the only group of filamentous fungi possessing a large nonmotile egg fertilized by a small uniflagellate sperm. This has led to considerable study and speculation on the origin and relations of this group to other fungi and to certain of the algae. Further details of this family may be found in the most recent monograph of the group by Sparrow (1933), and in the comprehensive publication on aquatic Phycomycetes by Sparrow (1943).

Species of *Monoblepharis* are found primarily in permanent fresh water habitats on dead submerged twigs. These are found most frequently in cool waters early in the spring. Certain twigs, especially those of ash and birch, are more suitable for the requirements of the fungus. Species in the genus *Monoblepharella* have been isolated from wet soils in the sub-tropics or tropics. The habitat of *Gonapodya* is usually on twigs or submerged apple and rosaceous fruits.

Representatives of two of the three genera, and possibly of the third also, have been isolated from numerous collections of water and soil samples taken throughout the state of Illinois. Species in this family are rarely observed immediately after the twigs are brought in from the field and examined. However, when such twigs are put in charcoal treated filtered sterile distilled water at 8°C. to room temperature, tufts or pustules of delicate, pale-gray hyphae may appear over the twigs or only in openings of the lenticels. A temperature ranging from 8-11°C. is more favorable for the development of sporangia, while sexual reproductive structures develop more readily at room temperature. Some of the isolates remained sterile in spite of repeated attempts to induce sexual reproduction.

Species of the Monoblepharidaceae have certain well-defined characteristics that readily distinguish them from other groups in the Phycomycetes. The tufts of delicate hyphae extending from the lenticels of a twig consist of a rhizoidal system for

* The writer wishes to express his sincere appreciation to Dr. Leland Shanor for his helpful suggestions and advice in the preparation of this paper.

anchorage and absorption of foods, and slender straight branches. The well-developed filamentous mycelium contains protoplasm with regularly arranged vacuoles and oil globules, giving a foamy appearance. The hyphae may be terminated by sporangia which liberate posteriorly uniflagellate zoospores. These zoospores usually have an anterior group of refractive globules. After the zoospores leave the pore of the sporangium, they swim around for a time before settling on some suitable substratum, encysting, and germinating. In sexual reproduction, when known, the large, nonmotile egg, usually borne singly in each oogonium, is fertilized by a small posteriorly uniflagellate antherozoid. These are usually formed in an antheridium nearby on the same hypha. The fertilized egg becomes a thick-walled oospore that develops hyphae upon germination.

Out of a total of seven species of *Monoblepharis* that have been found in the temperate regions, the following species and one variety of the genus *Monoblepharis* have been collected in the state of Illinois. *Monoblepharis sphaerica* Cornu and *Monoblepharis polymorpha* Cornu have been encountered frequently, but *Monoblepharis macrandra* (Lagerheim) Woronin appears to be less common. *Monoblepharis macrandra* var. *laevis* Sparrow has been obtained only twice from these collections in Illinois. Sterile forms resembling *Monoblepharis regignens* Lagerheim and *Monoblepharis ovigera* Lagerheim have also been isolated. Some students of *Monoblepharis* and related genera have indicated that what we now know as *M. regignens* and *M. ovigera* might represent species of *Monoblepharella* if their method of sexual reproduction were known. Laibach (1927) has placed both of these in a separate genus, *Monoblepharіopsis.*

In the genus *Monoblepharis* the oospores are formed outside at the orifice of the oogonium or within the oogonium when sexual reproduction is known. The zygote is not flagellate. These two characteristics readily distinguish this genus from the genus *Monoblepharella.* The oospores in the genus *Monoblepharella* are formed outside of the oogonium and usually remote from it, while the zygote is flagellate and free-swimming. The hyphae in some species of *Monoblepharella* may develop swellings, a condition not observed in *Monoblepharis.* The sporangia are also comparatively wider and the zoospores are frequently produced in more than one row in *Monoblepharella.*

The genus *Gonapodya* is readily distinguished by its characteristic hyphae which have pseudosepta and which are usually constricted. Sexual reproduction is unknown in the genus. The hyphae are more irregular and frequently dichotomously branched, and the sporangia proliferate one to many times.

The characteristics and distribution of species found in Illinois follow:

Monoblepharis macrandra has antheridia that are usually conspicuously exserted as shown in figues 1, 2, and 3. The antheridia occur in younger plants on separate branches from the oogonia and in older ones they are hypogynous to the oogonia, the antheridia being strongly exserted. In this species the oospores normally have a thick brown wall covered by lighter colored bullations. This species was collected on ash twigs in a pond near the Kaskaskia River, Vandalia, Ill., April 22, 1947; on ash twigs in a pond near the little Wabash River, 4 miles east of Mason, Ill., April 22, 1947; and on poplar twigs in a pond near the Sangamon River, Riverton, Ill., May 11, 1947.

Monoblepharis macrandra var. *laevis* is similar to *M. macrandra* in the structure of the hyphae and the reproductive organs. A distinguishing difference as illustrated by figures 4 and 5, is the lack of any bullations on the oospore, making the thick dark brown wall smooth. Isolates of this species were found several times on elm twigs, in a pond, south of Yorkville, Ill., May 26, 1947.

Monoblepharis polymorpha is distinguished by the development of antheridia that are epigynous or appear to be inserted on the oogonia as illustrated in figures 6, 7, and 8. Isolates of this species have been found on hickory twigs in the Rocky Run, 7 miles south of Warsaw, Ill., May 20, 1947; on elm twigs in a pond south of Yorkville, Ill., May 26, 1947; and on ash twigs in a pond in Evansville, Ill., June 2, 1947.

The most commonly isolated species, *Monoblepharis sphaerica* is separated from other species which produce sexual reproductive structures by the formation of antheridia that are hypogynous, or immediately below the oogonia, and an antheridial tube which is scarcely exserted beyond the wall of the antheridium. These characteristics and the sporangia are illustrated in figures 9, 10, 11, 12, 13, and 14. This species has been collected on willow twigs in the Kaskaskia River, Shelbyville, Ill., April 22, 1947; on ash twigs in a pond, East Peoria, Ill., May 4, 1947; on oak twigs in the Illinois River, 10 miles northwest of Grafton, Ill., May 10, 1947; on elm twigs in a pond south of Yorkville, Ill., May 26, 1947; and on birch twigs in a branch of the Rayse Creek, 5 miles west of Mt. Vernon, Ill., June 3, 1947.

Both of the two recognized species of *Gonapodya* have been collected in Illinois. *Gonapodya prolifera* (Cornu) Fischer has long pod-shaped or siliquiform sporangia in contrast to the long oval sporangia of *Gonapodya polymorpha* Thaxter as illustrated in figures 15 and 16. The later species is more open and ramose than *G. prolifera,* and it is also usually found under less foul environmental conditions. *Gonapodya prolifera* was collected on *Crataegus* fruits taken from Six Mile Creek, 5 miles south of Bloomington, Ill., Oct. 20, 1947, and *G. polymorpha* was found on elm twigs removed from Middle Fork, near Benton, Ill., June 3, 1947.

Isolates of a very delicate fungus resembling the asexual aspects of *Monoblepharella* or the incompletely known species, *Monoblepharis regignens* Lagerheim and *Monoblepharis ovigera* have been recovered more frequently in this area than species with sexual reproductive structures present. Figure 17 shows a portion of a hypha of an isolate lacking sexual reproduction, showing a typical sporangium. These may extend up to 85 microns in length, a size more characteristic of the sporangia of the tropical species, *Monoblepharella elongata* Springer. The group of sporangia illustrated in figure 18 is characteristic of *Monoblepharis ovigera.* The swellings on some of the hyphae of one of the isolates, as shown in figure 19, are more characteristic of species of *Monoblepharella,* although it has failed to reproduce sexually. Attempts to induce sexual reproduction in these isolates by subjecting them to temperatures above those normally prevailing, a method used successfully by other investigators studying tropical and sub-tropical species, have not been productive when employed with these isolates obtained in Illinois.

Summary

The occurence of a large number of species in the small family Monoblepharidaceae is reported for Illinois. Out of a total of about 9 species reported for temperate climates, the following species have been isolated from the numerous collections of water and soil samples taken throughout the state. *Monoblepharis sphaerica* Cornu and *Monoblepharis polymorpha* Cornu have been encountered frequently, but *Monoblepharis macrandra* (Lagerheim) Woronin appears to be less common. *Monoblepharis macrandra* var. *laevis* Sparrow has been isolated twice from these collections. Both *Gonapodya prolifera* (Cornu) Fischer and *Gonapodya polymorpha* Thaxter have been found in this area. Isolates that failed to reproduce sexually and resemble the asexual aspects of species of *Monoblepharella* or the incompletely known species, *Monoblepharis regignens* Lagerheim and *Monoblepharis ovigera* Lagerheim, have been recovered frequently.

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Plate I

Explanation of Figures

Figs. 1-3. *Monoblepharis macrandra.* Figure 1 contains a young oogonium. Figure 2 shows the antheridium and oogonium separate, a condition occurring in young plants. In figure 3, a portion of the hypha showing sex organs with the antheridium hypogynous and strongly exserted.

Figs. 4-5. *M. macrandra* var. *laevis.* Both figures show portions of plants with antheridia and oogonia which have smooth-walled, exogenous oospores.

Figs. 6-8. *M. polymorpha.* These figures show portions of hyphae with sex organs that have antheridia appearing to be epigynous or inserted on the oogonia.

Figs. 9-14. *M. sphaerica.* Figures 9, 10, and 11 show portions of hyphae with oogonia, exogenous oospores and antheridia with slightly exserted antheridial tubes. Figure 10 also shows an empty sporangium. Figure 12 shows a hyphal tip with a young oogonium developing. Figure 13 illustrates another hypha terminated with sex organs. Figure 14 represents a portion of the plant with several sporangia.

Fig 15. *Gonapodya prolifera*, a small part of the plant showing hyphal segments and proliferated sporangia.

Fig. 16. *G. polymorpha*, a portion of the plant illustrating the ramose habit and some sporangia still proliferating.

Fig. 17. A portion of an isolate apparently lacking sexual reproduction, but producing long sporangia similar to *Monoblepharella elongata.*

Fig. 18. A portion of a plant which has not produced sex organs, showing a group of sporangia characteristic of *M. ovigera.*

Fig. 19. Sporangium on an apparently sterile hypha with swellings characteristic of some species of *Monoblepharella.*

All figures were made with the aid of a Spencer camera lucida. The magnifications of all the figures are approximately X258.

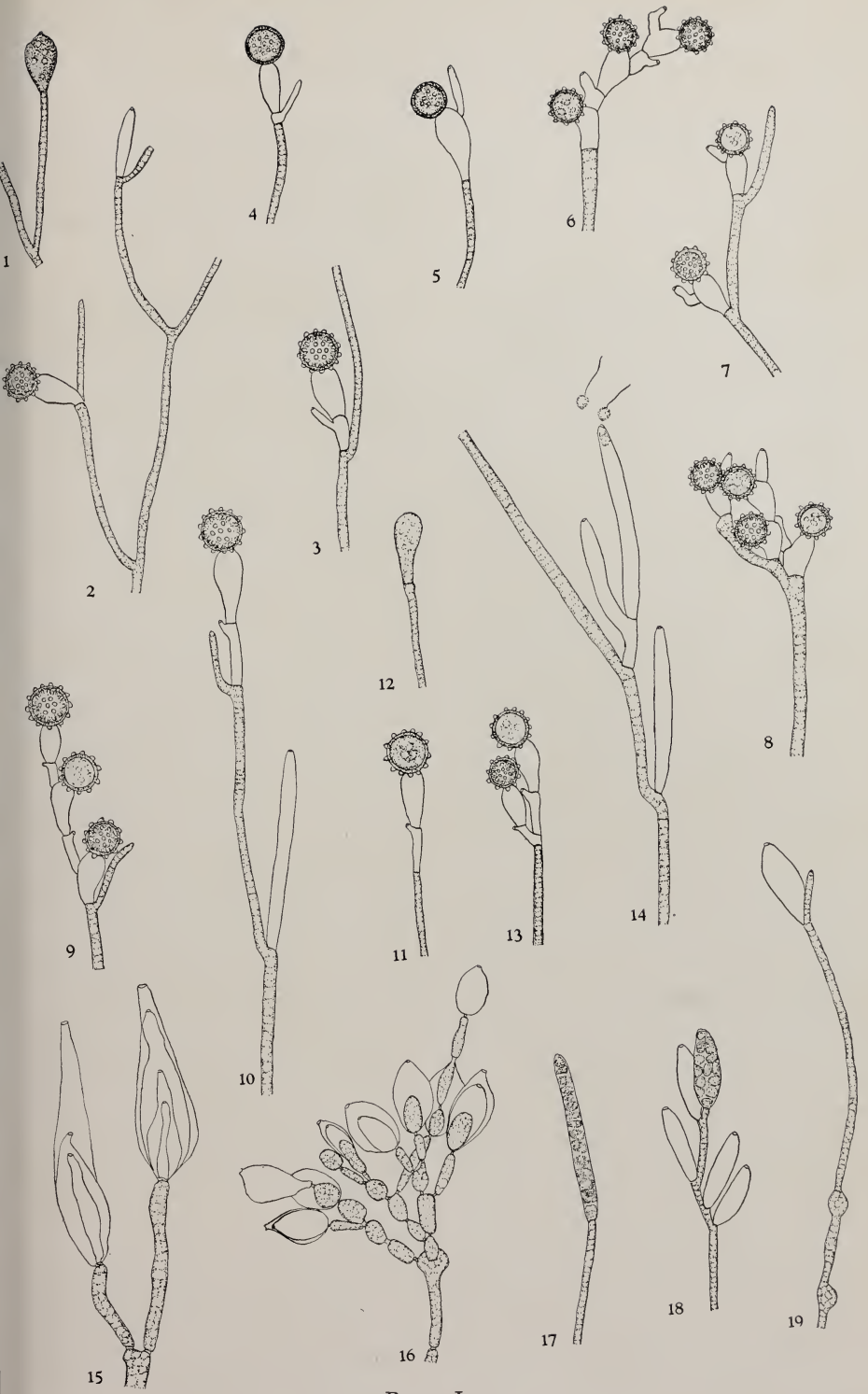

PLATE I

THE GENUS *ANEMONE* IN ILLINOIS

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The genus *Anemone* is represented in Illinois by six known species. This taxonomic study is an attempt to evaluate the genus in Illinois from a study of herbarium specimens in the University of Illinois herbarium and the herbarium of the Illinois State Natural History Survey. Descriptions have been made of the salient features of the species; an artificial key is provided for their identification.

Type localities of the species are from their original descriptions; the distribution in North America has been adapted from Rydberg's *Flora of the Prairies and Plains.* Habitats have been recorded from information on herbarium labels. Common names are those given in *Standardized Plant Names.* The synonymy of each species is not intended to be exhaustive; only those synonyms are listed to which reference as to their occurrence in Illinois is recorded. Cited specimens are from the herbaria of the University of Illinois and from the Illinois State Natural History Survey (NHS).

Anemone L.
(*Pulsatilla* Adans.)

Erect, perennial herbs usually with horizontal rhizomes and basal leaves. Basal leaves petioled, palmately divided or dissected. Stem leaves whorled, forming an involucre remote from the flower. Flowers terminal, solitary or umbellate. Sepals 4-20, usually 5, petals lacking. Stamens numerous. Pistils usually numerous, maturing into achenes. Style persistent, short, or developing a long and plumose tail.

Opinions vary as to the limits of the genus *Anemone,* it having been variously divided by some authors into several genera, or these several genera combined by others into the one genus. Tournefort recognized both *Anemone* and the closely related *Pulsatilla.* Linnaeus, in the early editions of the *Genera Plantarum,* listed *Hepatica, Anemone* and *Pulsatilla,* but combined all three of these as *Anemone* in the first edition of the *Species Plantarum.* Later, Adanson recognized *Anemone* and *Pulsatilla.* In Gray's Manual the first four editions maintain *Pulsatilla* and *Anemone* as distinct from each other, but later editions include both under *Anemone.*

Hepatica, in which the involucre is close to the flower and is sepallike, is a natural genus readily separated from *Anemone* and *Pulsatilla.* The latter groups are not as easily distinguished. The long plumose style and the occasional presence of abortive stamens of *Pulsatilla* are the only obvious characters which separate it from *Anemone.* In other respects, especially in the remoteness of the involucre from the flower and the similarity of perianth parts in both, the two are closely enough allied to include them in one genus, as they are so considered in this report.

Key to Species

1. Styles elongate, plumose; plants villous; leaf segments linear; sepals bluish-purple. *A. ludoviciana*
1. Styles shorter, glabrous or pubescent, not plumose.
   2. Stem leaves sessile.

3. Stem 2-6 dm. tall, arising from a rhizome; sepals 4-6, obovate, white. *A. canadensis*
3. Stem 8-20 cm. tall, arising from a small tubercle; sepals 6-20, linear, white or purplish. *A. caroliniana*

2. Stem leaves stalked.
4. Basal leaves numerous, simple, divided; flowers 1-several; achenes villous.
5. Leaf segments toothed above the middle, cuneate; styles 1 mm. long. *A. cylindrica*
5. Leaf segments toothed to below the middle, ovate to ovate-lanceolate; styles 1.5-2 mm. long.

4. Basal leaf solitary, compound, appearing after the flower; flower solitary; achenes glabrous or pubescent. *A. quinquetfolia*

Anemone ludoviciana Nutt. Gen. Am. Pl. II: 20, 1818; Jones (1945) 131; Fuller (1946) 56.

Clematis hirsutissima Pursh, Fl. Am. Sept. 385, 1814.

Pulsatilla nuttalliana Spreng. Syst. II: 663, 1825; Bebb (1860) 183.

A. patens var. nuttalliana A. Gray, Man. Ed. 5: 36, 1867; Vasey (1870) 217; Patterson (1876) 1; Brendel (1887) 83; Higley & Raddin (1891) 1; Huett (1897) 2:163.

A. patens var. Wolfgangiana sensu McDonald (1890) 103; Robinson and Fernald (1908) 401; Gleason (1910) 155; Pepoon (1927) 208; not Koch.

P. hirsutissima (Pursh) Britt., in Ann. N. Y. Acad. Sci. 6: 217, 1892; Britton (1892) 217.

P. ludoviciana (Nutt.) Heller, Cat. N.A. Pl., Ed. 2:4, 1900; Rydberg (1932) 333.

P. patens sensu Britton and Brown (1913) 2: 102. Not (L.) Mill., Mill. Gard. Dict., Ed. 8, No. 4, 1768.

Type locality: "Commencing near the confluence of the river Platte and Missouri; on gravelly hills."

Range: Ill.—Tex.—Utah—Wash. —Alaska.

Perennial from a thick rhizome. Stem villous, 15-35 cm. tall. Leaves dissected into numerous divisions; basal leaves petioled, involucral leaves sessile. Peduncle bearing a solitary large purple or white flower. Sepals 5-7, ovate. Stamens numerous, the outer often sterile. Achenes in a globose head, with long plumose persistent styles. Amercian Pasque Flower.

In prairies, northern Illinois. Rare.

The earliest flowering and rarest species in Illinois, occurring only in the northernmost counties.

Specimens examined: McHenry Co. Ringwood, no date, G. Vasey; Ogle Co. Byron, 1885, Blount; Winnebago Co. Fountaindale, no date, M. S. Bebb; Rockford, March 30, 1910, J. G. Mosier; prairies, Rockford, April 16, 1940, April 19, 1940, G. D. Fuller (NHS).

Anemone canadensis L. Syst., Ed. 12, 3, App.: 231, 1768; Gleason (1910) 155; Britton and Brown (1913) 2: 99; Gates (1922) 167; Fuller (1925) 102; Gates (1926) 228; Pepoon (1927) 311; McDougall and Liebtag (1928) 228; McDougall (1936) 105; Jones (1942) 71; Fuller (1943) 94; Jones (1945) 131; Fuller (1946) 56.

A. pennsylvanica L. Mant. 2: 247, 1771; Beck (1828) 115; Mead (1846) 35; Forbes (1870) 352; Greene (1870) 6; Babcock (1872) 20; Patterson (1874) 1; Schneck (1876) 514; Higley and Raddin (1891) 2; Huett (1879) 43; Snare & Hicks (1898) 1.

Type locality: "Hab. in Pennsylvania."

Range: Lab.—Que.—Alta.—Colo. —Mo.—Md.

Stem 2-6 dm. tall, branching at the involucre, sparingly pubescent. Basal leaves long petioled, hairy, 3-5 lobed, the lobes dentate. Involucral leaves 3, sessile; secondary involucre often present. Flowers on long naked peduncles. Sepals 4-6, obovate, white. Head of achenes globose. Achenes pubescent, winged, style persistent, as long as or longer than the achene. Meadow Anemone.

Woods and moist places, northern and central Illinois.

A. dichotoma L., a Siberian species, closely resembles *A. canadensis*, differing from the latter in its narrower, oblong leaf segments and

glabrous, ovate achenes. Brendel (1887) 43, attributes *A. dichotoma* to the Peoria region; an examination of one of his specimens so labeled shows it to be *A. canadensis.*

Specimens examined: Adams Co. Bottoms around Big Lake, 3 miles south of Quincy, May 29, 1943, Rev. Brinker (NHS). Bureau Co. Normandy, May 29, 1946, Boewe (NHS). Calhoun Co. Low swales, Pepoon and Barrett, May 30, 1932 (NHS). Cass Co. Moist field, Meredosia, June 7, 1942, G. D. Fuller. Champaign Co. Without definite locality, June 28, 1886, M. B. Waite; woods, Urbana, June 5, 1900, Clinton; forest border, Urbana, July 26, 1928, McDougall; roadside, east of Urbana, May 24, 1929, S. J. Ewer; edge of thicket near Urbana, June 6, 1940, G. N. Jones; Sangamon River, near Mahomet, July 20, 1940, G. N. Jones; without definite locality, Gregory, No. 14002. Christian Co. Taylorville, 1887, DeMotte; Taylorville, no date, DeMotte; "Half Acre," Taylorville, May 22, 1897, W. Andrews. Cook Co. Damp ground, DesPlaines valley, May 25, 1896, A. Chase. Du Page Co. Wheaton, no date, Moffatt; Naperville, May 30, 1915, Keinholz. Ford Co. Moist ground near Paxton, May 29, 1940, G. N. Jones. Hancock Co. Cedar Glen, July 26, 1917, F. C. Gates. Henry Co. Damp meadows, Galva, June 1883, McDonald; prairie roadside near Galva, May 24, 1908, V. H. Chase; roadside south of Kewanee, May 29, 1946, Boewe (NHS). Jo Daviess Co. Apple River Canyon State Park, June 17, 1943, G. N. Jones, G. D. Fuller (NHS). Kankakee Co. Open woods and thickets, May 31, 1873, E. J. Hill; St. Anne, June 16, 1940, G. N. Jones. Kendall Co. Roadside north of Lisbon, May 28, 1946, Boewe (NHS). La Salle Co. Starved Rock State Park, June 5, 1939, D. T. Ries (NHS), May 27, 1939, F. G. Werner (NHS). Lake Co. Beach region north of Waukegan, June 16, 1909, F. C. Gates. Lee Co. Roadside south of Dixon, May 27, 1946, Boewe (NHS). Logan Co. West of Lincoln, June 18, 1930, L. R. Tehon; along Route 10 near Logan-DeWitt Co. line, May 29, 1946, Boewe (NHS); roadside near New Holland, May 29, 1946, Boewe (NHS). Macon Co. Damp woods east of Decatur, May 30, 1915, I. W. Clokey. Madison Co. Cahokia bottom, May 13, 1916, Drushel. Mason Co. Lake Matanzas, July 23, 1910, F. C. Gates. McHenry Co. Algonquin, June 14, 1878, Nason. Ogle Co. Oregon, July 8, 1882, M. B. Waite; White Pines Forest State Park, May 30, 1942, May 24, 1942, A. L. Hills. Peoria Co. Damp ground, Peoria, June 1889, McDonald. Stark Co. Clay bank north of Wady Petra, May 29, 1897, June 9, 1907, V. H. Chase. Wabash Co. Shannon's swamp, Mt. Carmel, July 21, 1882, Schneck. Winnebago Co. Above Rockford, July 23, 1933, Pepoon and Barrett (NHS).

Anemone caroliniana Walt., Fl. Car. 157: 1788; Lapham (1857) 500; Brendel (1859) 586; Patterson (1874) 1; Boltwood (1880) 71; Higley & Raddin (1891) 1; Huett (1897) 43; Robinson & Fernald (1908) 401; Gleason (1910) 155; Britton & Brown (1913) 2: 98; Pepoon (1927) 308; Jones (1945) 131.
A. tenella Pursh, Fl. Am. Sept. II: 387, 1814; Beck (1828) 115.

Type locality: "Carolina."

Range: Wis.—S. D.—Tex.—Fla.—N. C.

Perennial from a short thick rhizome. Stem 8-20 cm. tall, sparingly pubescent, stout. Leaves 3-divided; basal leaves petioled, often much toothed; stem leaves sessile. Sepals 6-20, bluish or white, pubescent outside, glabrous within. Achenes villous, in a cylindrical head. Carolina Anemone.

Bluffs and open places, central and northern Illinois. Rare.

This species may be confused with *A. decapetala* Ard. of more southern distribution. In the latter species the basal leaves are merely crenate. It is doubtful that *A. decapetala* occurs in Illinois. Brendel (1887) 43, cites it as occuring in the Peoria region. An examination of Brendel's specimen shows it to be *A. caroliniana.*

Specimens examined: Henderson Co. Banks of Mississippi River near Oquawka, May 18, 1873, Patterson. LaSalle Co. Sandy field, Utica, April 27, 1941, G. D. Fuller. Lee Co. Bank of Rock River, Dixon, May 21, 1860, E. J. Hill. Macon Co. Blue Mound, May 4, 1901, Andrews. Mason Co. Havana, April, 1942, T. H. Frison (NHS). Peoria Co. Dry gravelly slopes near Peoria, Apr. 1900, Apr. 1903, F. E. McDonald; Peoria, no date, Brendel. St. Clair Co. Mascoutah, no date, W. Welsch.

Anemone cylindrica A. Gray, Ann. Lyc. N.Y. III: 221, 1836; Lapham (1857) 500; Bebb (1860) 183; Greene (1870) 6; Babcock (1873) 248; Patterson (1876) 1; Brendel (1887) 43; Higley & Raddin (1891) 1; Huett (1897) 43; Snare & Hicks (1896) 1; Gleason (1910) 155; Gates (1912) 359; Sampson (1921) 563; Fuller (1925) 8; Thone (1925) 100; Pepoon (1927) 311; McDougall (1936) 104; Deam (1940) 461; Fuller (1943) 94; Jones (1945) 131; Fuller (1946) 56.

Type locality: "In dry pine barrens, near Oneida Lake, New York."

Range: Que.—B.C.—Ariz.—Kan. —Ill.—Pa.

Perennial. Stem 2-6 dm. tall, pubescent, branching above, stout. Leaves on long petioles, 3-divided, the divisions toothed above the middle; teeth obtuse to acute; leaf divisions cuneate. Involucral leaves 3-18. Flowers several, on long peduncles. Achenes villous, tipped with the minute styles, borne in a cylindrical head 2.5 cm. or more long. Candle Anemone.

Open woods, central and nothern Illinois, common.

Specimens examined: Champaign Co. No definite locality, June 22, 1876, Savage; no definite locality, June 19, 1896, M. B. Waite; Urbana, June 28, 1886, M. B. Waite. Cook Co. Sandy woods, South Chicago, July 9, 1875, E. J. Hill; sandy woods, Evanston, June 15, 1896, A. Chase; sunny woods, Evanston, June 15, 1896, A. Chase; dry field, Evanston, June 17, 1896, A. Chase; Rogers Park, August 16, 1896, Moffatt; near Addison, August 12, 1938, J. C. Carter (NHS). Du Page Co. Railroad east of Andrews, June 18, 1937, R. J. Dobbs (NHS). Kankakee Co. Dry woods near Waldron, July 10, 1873, E. J. Hill; barrens near St. Anne, June 12, 1932, Pepoon & Barrett (NHS). Lake Co. Beach region north of Waukegan, June 29, 1908, F. C. Gates; along Lake Michigan, Waukegan, Aug. 18, 1906, Gleason & Shobe; Libertyville, Sept. 7, 1912, E. Sherff. LaSalle Co. Starved Rock State Park, No. 137, Thone. Macoupin Co. Carlinville, June 7, 1880, Robertson (NHS). McHenry Co. Algonquin, July 13, 1878, June 21, 1878, Nason. McLean Co. Prairie, Normal, July 18, 1881, Seymour. Ogle Co. Gales Hill, Oregon, July 7, 1885, M. B. Waite. Peoria Co. Open woods, Peoria, June 18, 1889, F. E. McDonald; Peoria, no date, Brendel; dry slopes, Peoria, July 1903, F. E. McDonald. St. Clair Co. Mascoutah, no date, W. Welsch. Winnebago Co. Rockford, June 13, 1940, July 12, 1940, G. D. Fuller (NHS); west of Shirland, June 10, 1946, E. W. & G. B. Fell.

Anemone virginiana L. Sp. Pl. 540, 1753; Beck (1828) 115; Mead (1846) 35; Babcock (1872) 20; Patterson (1874) 1; Schneck (1876) 514; Brendel (1887) 43; Higley & Raddin (1891) 1; Gleason (1910) 155; Gates (1912) 359;

Fuller (1925) 8; Pepoon (1927) 311; Jones (1942) 71; Fuller (1943) 94; Jones (1945) 131; Fuller (1946) 56.

Type locality: "Habitat in Virginia."

Range: Que. — S. C. — Kan. — Wyo.—Alta.

Stem pubescent, 5-9 dm. tall, branching at the involucre. Basal leaves long petioled, 3-divided, the divisions toothed to below the middle, the margins serrate; divisions ovate to ovate lanceolate. Involucral leaves 3, short petioled. Flowers on long naked peduncles, sepals 5, white. Achenes villous, tipped by the subulate style. Head of fruit oblong, 1.8 to 2.5 cm. long. Virginia Anemone.

Woods and moist places; the commonest species in Illinois.

Specimens examined: Adams Co. Woods near Coe Springs, August 15, 1941, R. Evers (NHS); Fall Creek Gorge, July 19, 1941, Evers & Jones, No. 633, No. 675. Boone Co. Shady bank of slough northwest of Belvidere, June 14, 1946, E. W. & G. B. Fell. Carroll Co. Wooded hillside, Savana, July 12, 1902, A. Chase. Champaign Co. Urbana, July 15, 1886, M. B. Waite; Urbana, Oct. 1898, "GPC"; railroad, Seymour, July 5, 1928, McDougall; Sangamon River near Mahomet, July 20, 1940, G. N. Jones. Christian Co. Taylorville, June 19, 1889, June 25, 1899, June 26, 1897, Andrews. Coles Co. Fox Ridge State Park, Sept. 16, 1939, G. N. Jones, Aug. 21, 1941, Rennels (NHS); open woods near Charleston, Sept. 9, 1946, G. N. Jones. Cook Co. Washington Heights, June 1884, Moffatt; woods, Prospect Park, August 1887, Moffatt; woods, Glen Ellyn, June 20, 1894, Moffatt; damp woods, River Forest, July 7, 1896. A. Chase; wooded banks of Des Plaines River, Maywood, Sept. 9, 1900, A. Chase; woods, Thornton, July 14, 1902, Lansing. Fayette Co. St. Elmo, July 10, 1943, O'Dell; woods south of Ramsey, July 27, 1941, O'Dell. Franklin Co. Near Christopher, July 6, 1940, G. N. Jones. Jo Daviess Co. Apple River Canyon State Park, June 17, 1943, G. D. Fuller (NHS). Kane Co. Clearings, Elgin, Sept. 22, 1912, E. Sherff. Kankakee Co. Woods and thickets, Durham's Grove, July 18, 1873, E. J. Hill; woods and thickets, Kankakee, July 8, 1873, E. J. Hill. Knox Co. Wooded hills near Williamsport, July 5, 1908, V. H. Chase. Lake Co. Channel Lake, Antioch, Aug. 14, 1906, Gleason & Shobe; beach region north of Waukegan, July 19, 1909, F. Gates. Lee Co. North of Prairieville, Oct. 31, 1945, Boewe (NHS). McHenry Co. Algonquin, July 5, 1878, Nason. Ogle Co. Oregon, July 18, 1882, M. B. Waite. Peoria Co. Dry open woods north of Princeville, July 21, 1898, V. H. Chase; rich woods, Peoria, no date, McDonald; Peoria, no date, Brendel. St. Clair Co. Valley twp. July 6, 1895, V. H. Chase. Vermilion Co. Woods, June 24, 1880, Seymour & Butts; along Vermilion River between Oakwood and Collison, July 14, 1940, G. N. Jones. Wabash Co. Walter's Farm, Mt. Carmel, June 30, 1878, Schneck; woods, Mt. Carmel, Sept. 15, 1888, Schneck. Winnebago Co. Woods and meadows, Rockford, June 24, 1940, G. D. Fuller (NHS); bank of Kishwaukee River, June 4, 1946, E. W. & G. B. Fell.

Anemone quinquefolia L. Sp. Pl. 541, 1753; McDonald (1890) 105; Fuller (1925) 8; Pepoon (1927) 311; Jones (1945) 131; Fuller (1946) 56.

A. nemorosa sensu Mead (1846) 35; Lapham (1857) 500; Warne (1870) 314; Babcock (1872) 20; Patterson (1876) 1; Schneck (1876) 514; Brendel (1887) 83; Higley & Raddin (1891) 2; Huett (1897) 43; Snare & Hicks (1898) 1; not L. (1753).

A. nemorosa var. quinquefolia A. Gray, Man. Ed. 5, 38, 1867; Higley & Raddin (1891) 2.

A. quinquefolia var. interior Fern., Rhodora 37: 260, 1935; Deam (1940) 460.

Type locality: "Habitat in Virginia, Canada."

Range: Que.—Man.—Iowa—Ohio.

Stem simple, 1-2 dm. tall. Stem leaves 3, petioled, 3-divided, toothed. Basal leaf solitary, on a long petiole, trifoliolate, appearing after the flower. Stem glabrous or pubescent. Flower solitary. Sepals 4-7, ovate, white. Head of achenes globose; achenes few to several, not wing margined, tipped with the recurved style. American Wood Anemone.

Moist woods, northern Illinois; not common.

Fernald (1935) describes as var. *interior* specimens from the Great Lakes region in which the stems are spreading villous. In a study of Illinois specimens variation from almost glabrous to spreading pubescent and spreading villous was found. Specimens of the same collection number showed similar variation. Although some specimens might be referred to the variety, the variability in the amount and type of pubescence indicates that no clear distinction can be made between *A. quinquefolia* and its variety *interior* in Illinois.

Specimens examined: Cook Co. Rich woods, Hog Island, May 3, 1876, E. J. Hill; sandy woods, Hyde Park, April 20, 1878, E. J. Hill; Grand Crossing, May 3, 1883, Schneck; Prospect Park, May 11, 1890, Moffatt; sandy soil, Evanston, April 28, 1897, A. Chase; River Forest, May 4, 1897, A. Chase; woods, Evanston, May 7, 1897, A. Chase; rich woods, Edgebrook, May 11, 1897, A. Chase; Leyden, April 28, 1906, F. C. Gates; moist rich woods, Thornton, May 20, 1944, G. D. Fuller (NHS). DuPage Co. Thicket north of Wheaton, no date, Moffatt; Naperville, April 26, 1915, Kienholz; rich oak woods, Wheaton, April 19, 1938, G. D. Fuller (NHS). Jo Daviess Co. No definite location, no date, Brendel; Apple River Canyon State Park, May 6, 1944, G. N. Jones. Kankakee Co. Open woods, Kankakee, May 17, 1873, E. J. Hill. LaSalle Co. Starved Rock State Park, May 6, 1939, Werner, May 4, 1939, D. T. Ries (NHS). McHenry Co. Algonquin, no date, A. L. Hills. Will Co. Rich woods, Mokena, May 7, 1902, A. Chase. Winnebago Co. Margin of woods, Rockford, May 14, 1940, G. D. Fuller (NHS).

Excluded Names

Anemone hepatica L. Sp. Pl. 538, 1753; Mead (1846) 35; Higley & Raddin (1891) 2.

This species is now designated *Hepatica americana* (DC.) Ker.

Anemone acutiloba (DC.) Laws. Trans. Nov. Scot. Inst. III: 30, 1870. Higley & Raddin (1891) 2.

This species is also referred to the genus *Hepatica*, as *H. acutiloba* DC.

Anemone thalictroides L. Sp. Pl. 542, 1753; Beck (1828) 115.

This species is now considered as *Anemonella thalictroides* (L.) Spach.

Summary

The six species of the genus Anemone in Illinois have been studied. Anemone is found throughout the state. In northern and central Illinois all six species are represented; in southern Illinois are found one *(A. virginiana)* or possibly two *(A. cylindrica)* species. Additional collections are needed to establish the range of these two species in Illinois. Four of the species *(A. canadensis, A. virginiana, A. cylindrica,* and *A. quinquefolia)* are typically found in woodlands and moist places. Two species of dry ground and prairies *(A. caroliniana* and *A. ludoviciana),*

both rare, occur in northern and central Illinois.

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THINNING RETURNS FROM AN EASTERN WHITE PINE PLANTATION IN OGLE COUNTY

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Early thinnings that can be made to pay their way or show a profit will put the management of forest plantations on a sound basis. As a general rule, thinning is usually delayed until the financial return will equal the expense of performing the operation. In plantation management the original spacing should be so chosen as to allow for proper development of planted trees without excessive competition with one another up to an age and size which will permit a profitable thinning. Utilization practices within a given area will determine the spacing. Even though not immediately profitable, early thinnings may be justified on the basis of over-all stand improvement and the fact that they will increase the increment of quality wood on pruned crop trees. It has been proved that the increment on pruned trees will return a profit at the time of harvest. Since a group of relatively few trees of large diameter on an area will yield much more lumber than numerous trees of small diameter, the advantage of concentrating growth on a small number of trees is evident. Forty-seven percent of the total yield and 35 percent of the total value of a pine-spruce stand in central Sweden was removed in the form of thinnings (3).

Four one-quarter acre permanent sample plots were established in a 32-year-old white pine plantation on Sinnissippi Forest, Ogle County, in 1939. These plots serve for thinning and pruning studies. Periodic measurements provide growth and yield information. The first thinning was made in the fall of 1941 at the age of 34. An earlier thinning would have resulted in better development and increased growth of the final crop trees. A second thinning was made in the fall of 1946 at the age of 39. Stand conditions before and after thining, together with material removed, are summarized in Table 1. In two plots the desired stocking was reduced by a severe wind storm, a plane crash and the death of several crop trees. Although the primary cause of death was not determined, the red-turpentine beetle *Dendroctonus valens,* was always associated with the dying trees.

The main purpose of the thinnings was to provide the pruned crop trees with sufficient growing space for their optimum development. Trees removed were principally in the codominant crown class with some in the dominant. Diameter growth of the intermediate-crown class was low, and the suppressed trees showed no growth for the five-year period. The suppressed trees were removed if large enough to yield a post. Their small undeveloped crowns aided little in site protection.

Sinnissippi Forest operates its own sawmill and a semicommercial treating plant for the preservation of fence posts (2). Some 2 to 3 thousand fence posts are treated annually. They are cold-soaked 48 hours in a 5-percent solution of pentachlorphenol in light fuel oil. The financial success of these thinnings was largely due to the ready sale of treated posts and rough lumber at near-by markets. Lumber and treated fence posts are retailed at the mill yard. Special orders are

TABLE 1—COMBINED DATA FOR FOUR ONE-QUARTER ACRE PLOTS
Eastern White Pine Thinning and Pruning Plots
Sinnissippi Forest, Ogle County

Age	Trees per acre	Basal area	Av. Height		Site index	Av. D. B. H.		Diam. range	Stand density	Volume per acre[a]	
			All trees	Dom. and codom.		All trees	Dom. and codom.			Trees 2″ and over	Trees 8″ and over
Years	No.	Sq. ft.	Feet	Feet	Feet	Inches	Inches	Inches	Index	Cu. ft.	Bd. ft.
					Stand before thinning						
34	636	181	42	46	72	7.2	8.2	3-15	375	3942	13,665
					Material removed in thinning						
34	148	38	40	..	..	6.9	...	3-12	...	821	2,742
					Stand after thinning						
34	488	143	43	46	72	7.3	8.2	4-15	294	3121	10,923
					Stand before thinning						
39	452	161	49	53	70	8.2	8.9	3-16	329	3937	17,869
					Material removed in thinning						
39	132	30	44	..	..	6.5	...	3-14	...	683	1,746
					Stand after thinning						
39	320	131	51	53	70	8.7	8.9	4-16	256	3254	16,123

[a] Volumes from Harvard Forest Bulletin No. 13, Form class 65.

Table 2.—Post and Lumber Yields from Four One-Quarter Acre Sample Plots

Plot No.	Select		No. 1		No. 2		Total		Board feet[a]	
	Age 34	Age 39	Age 34	Age 39	Age 34	Age 39	Age 34	Age 39	Age 34	Age 39
113	7	15	64	94	28	41	99	150	476	355
114	5	16	43	94	19	51	67	161	142	205
115	10	8	91	51	39	23	140	82	486	135
116	6	6	56	39	24	15	86	60	530	166
Per acre	28	45	254	278	110	130	392	453	1,634	861

[a] International log rule (sawkerf ¼ inch).
Post specifications: Minimum top D.I.B. of 6 inches for select, 4 inches for No. 1 and 3½ inches for No. 2.

delivered to Oregon and Rockford markets. Data on cost of growing these pine plantations with expected returns were published in 1944 (1).

All posts were graded for this study. The choice of post grades was arbitrary, although selected from the standpoint of farm demand. Lumber and post yields, together with specifications by grades, are listed in Table 2. In 1941 all graded posts were sold in mixed lots for 55 cents each. In 1946 they were sold by grade only. Select, No. 1 and No. 2 grades sold for 85, 75 and 65 cents respectively. The rough pine lumber was sold largely in the form of two-by-fours and inch boards. One specific order included finished knotty-pine boards for interior decoration.

Table 3 illustrates the method used to figure net stumpage appraisals for treated posts and lumber.

Table 4.—Thinning Yields and Net Stumpage Returns Per Acre

Age 34	391 fence posts @ 10c.	$ 39.10
	1,634 bd. ft. @ $23.00/M	37.58
	Total	$ 76.86
Age 39	453 fence posts @ 20c.	$ 90.60
	861 bd. ft. @ $37.00/M	31.86
	Total	$ 122.46
Total net stumpage returns		$ 199.14

The light sandy soils supporting these pine plantations are considered too poor for general farm use. Therefore, the total net stumpage returns of $199.14 per acre from these two thinnings is very encouraging from the standpoint of plantation management. It is possible that all costs of raising these pine plantations, including 3 percent compound interest, may be entirely liquidated by the next thinning.

TABLE 3.—STUMPAGE APPRAISALS FOR TREATED POSTS AND LUMBER
Eastern White Pine Thinning and Pruning Plots
Sinnissippi Forest, Ogle County

	Age 34 in 1941		Age 39 in 1946	
Average selling price per post		$.550		$.720
Production costs				
Cutting	$.101		$.136	
Peeling	.094		.138	
Hauling	.020		.015	
Treating solution	.120		.116	
Treating labor	.025		.019	
Equipment and depreciation	.015		.010	
Total of direct cost and depreciation	.375		.434	
Plus 20% of cost for profit and risk	.075		.087	
Total cost and margin		.450		.520
Indicated stumpage value per post		.100		.200
Average mill-run selling price				
1,634 bd. ft. at $65.00 in 1941		$106.21		
861 bd. ft. at $85.00 in 1946				$73.18
Logging and milling cost plus depreciation	$57.19		$34.44	
Plus 20% of cost for profit and risk	11.44		6.89	
Total cost and margin		68.63		41.33
Indicated stumpage value		37.58		31.86
Indicated stumpage value per M		23.00		37.00

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INITIAL REPORT ON THE VEGETATION OF McDONOUGH COUNTY, ILLINOIS[1]

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McDonough County is located in the west-central part of the state. It originally included 16 townships of approximately equal area (it now has 18) and has an area of 576 square miles. According to Hopkins et al. (1913) the elevation ranges from 500 to 775 feet above sea-level with an average of 690 feet. The greater part of the county is drained through the Lamoine River and its branches into the Illinois River. The principal streams extend in almost parallel lines toward the southwest. This part of the county is considerably dissected by erosion and is least suited to ordinary agriculture. Most of the county is covered with glacial drift from 10 to 140 feet thick, and considerable areas in the northern part are capped with loess up to 50 feet thick. Hopkins et al. (1913) have divided the soils into three main types: dark upland prairie soils, swamp and bottomland soils, and lighter colored upland timber soils. The average rainfall is 34.76 inches (Hambidge, 1941).

McDonough County, according to the geographic classification of Shelford (1931), is in the Macomb District of the Western Division of Illinois. In a map of the vegetation of the state Vestal (1931) showed that somewhat more than half of the county was originally prairie. The prairie, called the Bushnell Prairie, extended west into Warren and Henderson counties. Wright (1947) made a study of McDonough County prairies.

[1] The authors wish to acknowledge the invaluable assistance of R. M. Sallee of the biology department of Western Illinois State College, and that of George D. Fuller of the University of Chicago and the Illinois State Museum for checking the identification of most of the plants collected.

Methods Used in Studying the Vegetation

To reconstruct a picture of the original vegetation the following were consulted: (1) Histories of the county (Walters, 1885, and Alexander, 1907); (2) records of the land survey of the county which were completed in 1856; (3) report of the soils survey of the county (Hopkins et al. 1913). Field observations were also made.

Only limited observations have been made in all parts of the county. The most extensive reconnaissance and collecting were done in the central part where a timbered area with a minimum amount of disturbance and a relic area of prairie were studied. Very few records of plants collected in the county have been found and there is no adequate description of the flora. Miller and Tehon (1929) have mapped the distribution of the trees in the state by counties. They list only 10 trees for McDonough County. A herbarium has been started and is being developed with the objective of securing specimens and habitat data for all existing plants in the county. Duplicates are being sent to the Illinois State Museum.

Original Vegetation

The land survey of 1856 prepared manuscripts which give an apparently accurate picture of the vegetation at that time. The surveyors divided the county into townships and further subdivided it into sections and quarter sections. The corners of these divisions were located by posts in treeless areas and with

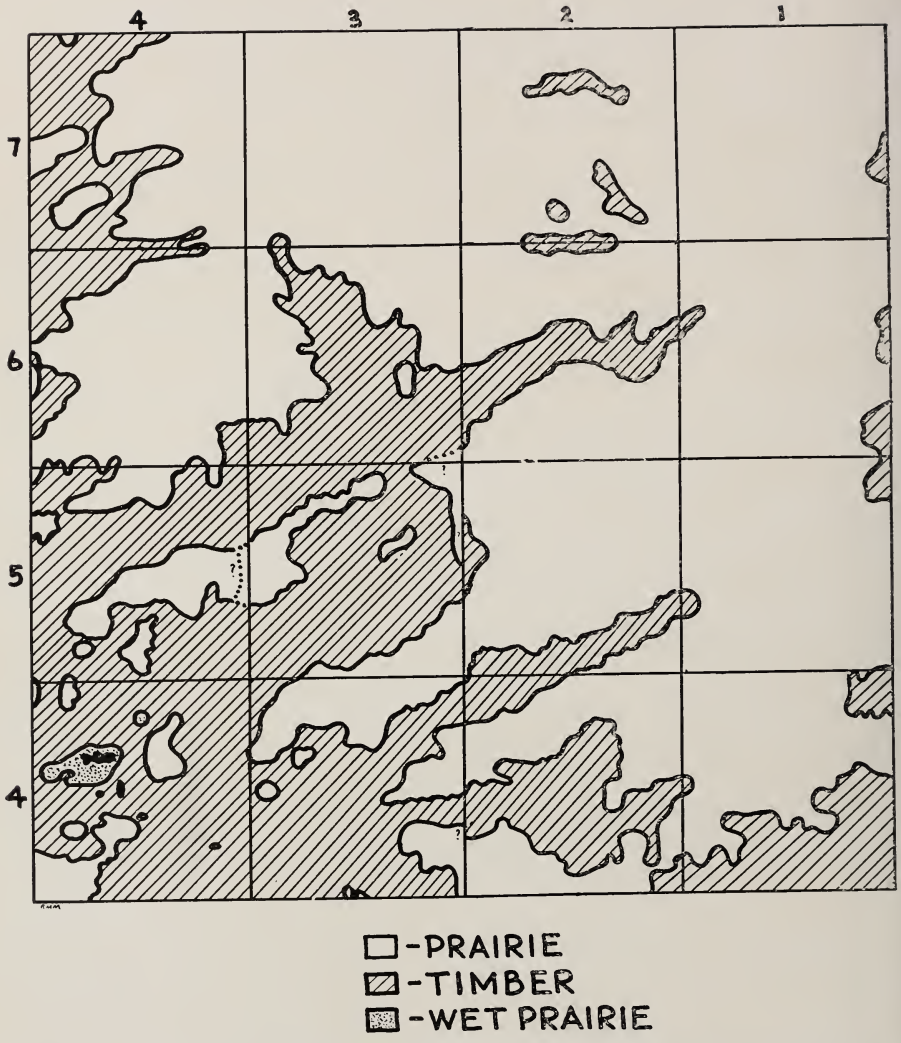

Fig. 1.—Prairie and timber areas of McDonough County as shown by 1856 survey records.

reference to trees in the timbered regions. The records include the species of trees, their diameter and their location. Sixteen species of trees were listed. The areas of timber and prairie were mapped for each township and then a composite map for the entire county was made. Some apparent errors were found, for instance Spanish oak was listed, and this now occurs only in the southern part of the state, and the boundaries of the vegetation types do not always coincide for adjacent townships. A map made from these data is shown in figure 1.

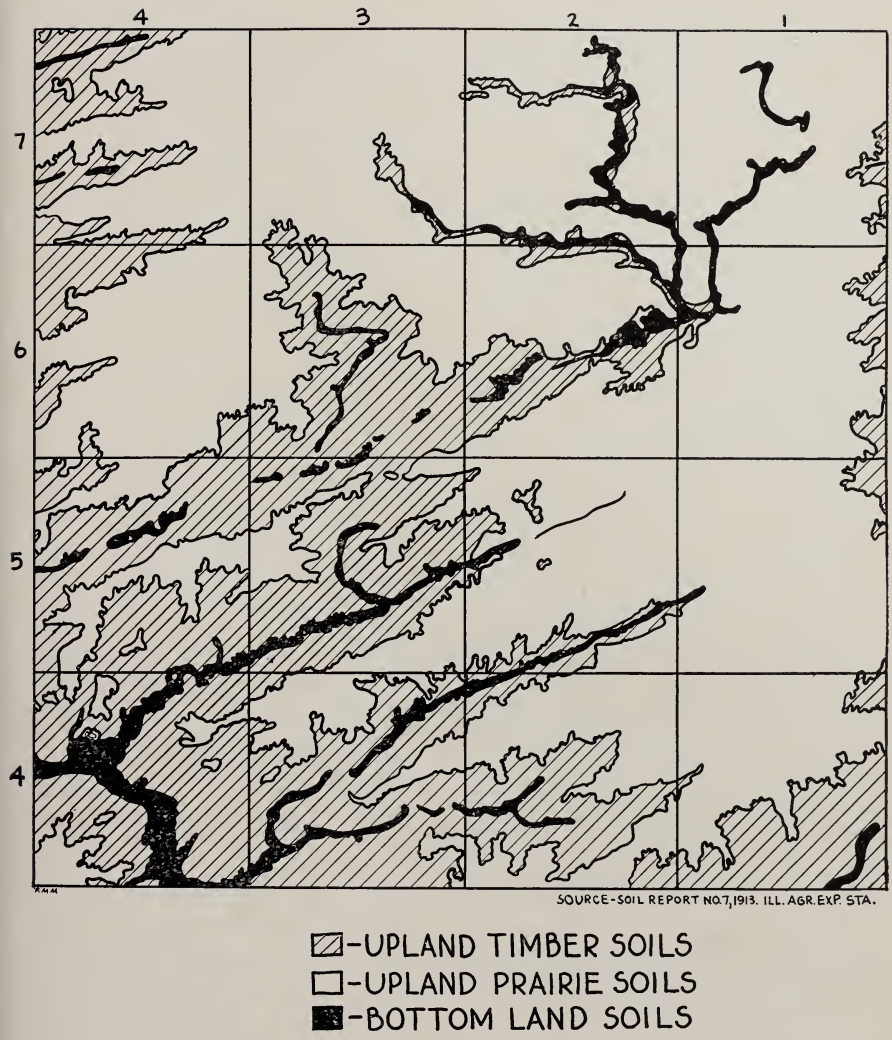

Fig. 2.—Distribution of timber, prairie, and bottomland soils of McDonough County. (Compare with fig. 1.)

Another map of the county was constructed based on the soils map of the county (Hopkins et al. 1913) to show the distribution of timber, prairie and bottomland soils (fig. 2). There is a close correlation with the map made by the 1856 surveyors. A less detailed map was made by Vestal (1931) from the same data for the entire state.

Some idea of the relative abundance of important tree species perhaps can be obtained by tabulating the number of times that a tree was listed in locating corners of the county divisions. The trees in Township 6 North and 3 West (Emmett) listed most often by the surveyors were white oak (49 times) and black oak (47 times) and other species

were listed altogether only 33 times. Table 1 gives a complete tabulation of all the trees listed. The present distribution of trees in this township is quite similar.

Table 1.—Number of Times that Certain Trees were Listed in Locating Section Corners in T. 5 N., R. 4 W. (Emmett)

White oak	49
Black oak	47
Hickory	15
Elm	6
Birch	3
Black Jack oak	2
Spanish oak (?)	1
Black walnut	1
Sugar tree	1
Maple	1
Buckeye	1
Mulberry	1
Linden	1

Township 4 North and 4 West (Lamoine) contains a considerable area of low lying land and in 1856 was mapped as containing four lakes and two areas of wet prairie as shown in figure 1. The trees listed by the surveyors indicate a wide distribution of pin oak. Pin oak was listed 32 times and white oak 59 times and black oak 27 times. Table 2 gives the complete tabulation.

Table 2.—Number of Times that Certain Trees were Listed in Locating Section Corners in T. 4 N., R. 4 W. (Lamoine)

White oak	59
Pin oak	32
Black oak	27
Hickory	26
Overcup oak (?)	21
Maple	9
Elm	7
Red oak	2
Hackberry	2
Cottonwood	2
Buckeye	1
Cherry	1
Ironwood	1
Linden	1
Spanish oak (?)	1

T. 7 N., R. 3 W. (Sciota) was shown as containing only a small tongue of timber extending up from the southwestern edge. Only 7 trees were used in locating division corners (Table 3) and the survey records indicated that these were in the small areas mapped as timber. The

Table 3.—Number of Times that Certain Trees were Listed in Locating Section Corners in T. 7 N., R. 3 W. (Sciota)

Hickory	2
Pin oak	2
Black oak	1
White oak	1
Linden	1

boundaries of this timbered area are practically the same now as they were in 1856. The rest of the township contains only a few scattered trees in the vicinity of farmhouses.

A history of the county (Alexander, 1907) states that originally there was a "splendid growth of oak, maples and black walnut" and that the smaller trees included ironwood, wild cherry, wild plum and others. In describing the open prairies at the time of early settlement it says, "And how delightful to recall even the fleeting visions and memories of those primitive days; the rushes and lilies of the sloughs and ponds; the delicious wild strawberries; the yellow ground cherries and other wild fruits that bloomed or ripened in the prairies of this favored land, . . . the countless varieties of wild flowers that profusely decked and perfumed this home of early settlers. Truly what a flower garden and orchard this prairie country was, not excelled by the modern creations of horticulture and floriculture!" A list of more than 100 flowering plants was included. Most of these are still found, but no collections of skunk cabbage, white trillium, red-berried elder, certain orchids and gentians which were listed have been made.

Present Vegetation

According to Telford et al. (1926) the original timber area decreased from 119,001 acres to 22,460 acres by 1924. The prairie has almost entirely disappeared. A small area of prairie was found recently a few miles from Macomb which included many typical prairie plants. Most of the area is well drained, but some is swampy. It is burned over nearly every year, but the sod is not plowed. Bunch flower *(Melanthium virginicum)* and the fringed orchid *(Habenaria leucophaea)* both listed by Jones (1945) as rare in Illinois were found in considerable numbers. Table 4 is a list of some of the plants that were collected here. These were included by Sampson (1921) in his list of plants in Illinois prairies. Of the 52 plants, 40 are included in his *Andropogon furcatus* association. It is hoped to make a more complete study of this area. Shelford (1931) stated that, "cut-off prairies in the western part of the Macomb district seem to likewise afford promise for detailed study."

Table 4.—Some Prairie Plants Found in a McDonough County Prairie[1]

(See text for a fuller explanation)

Equisetum arvense—Horsetail
Andropogon furcatus—Tall blue stem
Sorghastrum nutans—Indian grass
Panicum virgatum—Switch grass
Calamagrostis canadensis—Reed grass
Spartina pectinata—Cord grass
Hordeum jubatum—Foxtail grass
Cyperus spp.—Cyperus
Eleocharis sp.—Spike rush
Carex spp.—Sedges
Tradescantia canaliculata—Spiderwort
Juncus spp.—Rushes
Lilium michiganense—Wild lily
Hypoxis hirsuta—Star-grass
Salix humilis—Prairie willow
Anemone canadensis—Meadow anemone
Heuchera hispida—Alum root
Fragaria virginiana—Wild strawberry
Rosa carolina—Wild rose
Baptisia leucantha—Wild indigo
Desmodium sp.—Tick clover
Oxalis violacea—Violet wood sorrel
Euphorbia corollata
Viola papilionacea—Common blue violet
V. pedatifida—Prairie violet
Lythrum alatum—Loosestrife
Eryngium yuccafolium—Rattlesnake master
Lysimachia ciliata—Fringed loosestrife
Apocynum cannabinum—Hemp dogbane
Asclepias tuberosa—Butterfly-weed
A. syriaca—Common milkweed
A. verticillata—Horsetail milkweed
Phlox glaberimma—Smooth phlox
Lithospermum canescens—Gromwell
Monarda fistulosa—Bergamont mint
Pycnanthemum flexuosum—Mountain mint
Ruellia ciliosa—Wild petunia
Lobelia spicata—Lobelia
Vernonia missurica—Ironweed
Liatris sp. Blazing star
Solidago spp.—Goldenrods
Aster spp.—Asters
Silphium lacinatum—Compass plant
S. terebinathinaceum—Prairie dock
S. integrifolium—Rosin-weed
Parthenium integrifolium—American feverfew
Echinacea pallida—Pale coneflower
Ratibida pinnata—
Helianthus grosseratus—Sunflower
Coreopsis palmata
Cacalia tuberosa—Indian plantain

[1] The nomenclature of Jones (1945) is followed in this paper.

About five miles west of Macomb in T. 5 N., R. 4 W. (Emmett) is a rugged timbered area called Argyle Hollow. Some of it has been heavily pastured and all of it has been cut-over. More than 1,000 acres are being acquired by the state for a park. Extensive reconnaissance and collecting has been done in the least disturbed areas as much of it will be inundated by a lake to be built soon. The dominant trees of the uplands are white and black oaks *(Quercus alba, Q. velutina)* and shagbark hickory *(Carya ovata)*. Associated species include bur, post, black jack and shingle oaks *(Quercus macrocarpa, Q. stellata, Q. marilandica, Q. imbricaria)*, and pignut hickory *(Carya glabra)*. At the lower part of the ravines are sugar maple *(Acer saccharum)*, elms *(Ulmus americana, U. fulva)*, river birch *(Betula*

nigra), buckeye *(Aesculus glabra)*, and yellowbud hickory *(Carya cordiformis)*. The underlying herbs include trout lily *(Erythronium americanum)*, Dutchman's breeches *(Dicentra cucularia)*, bellwort *(Uvularia grandiflora)*, phlox *(Phlox divaricata)*, several ferns including the very common brittle fern *(Cystopteris fragilis)*, maiden hair fern *(Adiantum pedatum)*, broad beech fern *(Phegopteris hexagonaptera)*, ebony spleenwort *(Asplenium platyneuron)*, and many others. The present trees are similar in their distribution to that given by the surveyors in 1856 (Table 1).

Summary

1. The original and present vegetation of McDonough County, Illinois, is described. Data were secured by field observations, from histories of the county, from the survey records of 1856 which included maps of the timbered and prairie areas and lists of species of trees, and from soils maps. There was a close correlation between the soils of the county and the vegetation map of 1856.

2. A list of 52 prairie plants found in a relic area of prairie is given; 40 of these have been included by Sampson (1921) in the *Andropogon furcatus* association.

3. The distribution of common plants in a timbered area is described.

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CHEMISTRY

THE DYSONIAN SYSTEM OF ORGANIC NOTATION

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In the spring of 1947, G. M. Dyson, an English chemist, presented his new linear system of organic notation before the American Chemical Society. It was reviewed in The Chemical and Engineering New[1,2] and in the Journal of the American Chemical Society[3]. Soon thereafter, Dyson published a small book[4] giving more complete detail. He is not especially interested in superseding the present systems such as the Geneva but rather to make codification on punched cards more simple. Perhaps this is only a passing fancy, but it is so logical, so simple, and so useful that it may indeed be generally adopted. Therefore, it seems that every informed chemist should be conversant with it. In an address before the American Chemical Society in April 1948, Dyson related that he had made some changes which would appear in his revised edition.

In common with most English writers, his language is not as simple as we Americans are accustomed to. He uses the term "modulant" to refer to the number of atoms in groups. This is a full sized number (not a subscript or superscript) following the symbol such as C8 which implies a straight chain of eight carbons with the full number of hydrogens, which, of course, is understood. C8 is, therefore, n-octane, C_8H_{18}. The term "locant" refers to a number which precedes the group and gives its position in the system. Thus in C7.3C2, 7 and 2 are modulants and tell how many carbons; while 3 is a locant and tells where the C2 (ethyl group) is located in the seven carbon chain (heptane). C7.3C2 is, therefore, 3-ethyl heptane. Similar substituents on the same chain are numbered as in the Geneva system but without using any equivalent for di-, tri-, tetra-, etc. Thus C9.3,5C2 is 3,5-diethyl nonane. The largest branches are listed in decreasing size.

A denotes saturated rings. (Previously Dyson used AC, but apparently A signifies as much as AC.) A6 would be cyclohexane, C_6H_{12}. He is revising all the ring ciphers so they will be omitted here except for benzene which he formerly wrote B but now seems to write B6. B suggests aromatic character.

E is used for double bonds, E1, cis; E2, trans; E3, triple bonds. C4.1,3E is butadiene and C5.2E3 would be 2-pentyne.

Q is used for -OH. Thus B6.1,3,5Q is 1,3,5-trihydroxy benzene, C3.2C.2Q is tertiary butyl alcohol. Ethers are ciphered as C4.Q(C2) which is n-butyl ethyl ether.

Since E means unsaturated, EQ is double bond oxygen as in aldehydes and ketones. C4.EQ is n-butyraldehyde, but C4.2EQ is butanone.

X denotes the =O and -OH of the carbonyl group. Thus C3.X is CH_3-CH_2COOH for propionic acid and B6.CX(C2) for the ester, ethyl benzoate.

N means amine as C4.N for n-butyl amine; C3.NC2 is ethyl propyl

amine. Amides as C3.EQ(N) for propionamide.

N1 is nitroso; N2, nitro; then B6.N.4N2 means p-nitroaniline.

Halogens are shown by F, CL,BR, and I. B6.1,4I is p-di-iodobenzene. S and P with modifiers are used for those elements, sulfur and phosphorus respectively.

Carbohydrates are ciphered as C6.2 . . . 6QEQ.3L for d-glucose where 3L means that the third C has its -OH on the left. This may be shortened to G6.EQ.3L.

These do not begin to exhaust the varieties of conventions used but are presented here to give an idea of the system.

A very useful feature is the rapid method of calculating molecular formulas. The following is an abridged list of computing constants:

A ..... -2	N 1000001
B6.....604	N2.....1019999
C 102	Q 10000
E ..... -2	X 19998
E3..... -4	Halogens.....-1

The required numbers are added and pointed off two places at a time from the right to give the number of atoms of N, O, C, and H respectively reading from the left. Thus for:

B6.N: B6 604
N 1000001
Add 2
1000607
N O C H
C_6H_7N or $C_6H_5NH_2$

B6.N.4N2: B6 604
N 1000001
N2 1019999
Add 2
2020606
N O C H
$C_6H_6N_2O_2$ or $C_6H_4NH_2NO_2$

Likewise the following would be calculated, for example:

C2.Q.2N: C2 204
Q 10000
N 1000001
Add 2
1010207
N O C H
C_2H_7NO or $H_2NC_2H_4OH$

C3.2E3.X: C3 306
E3 -4
X 19998
Add 2
20302
O C H
$C_3H_2O_2$ or HC≡C-COOH

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QUANTIZED QUALITATIVE ANALYSIS

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Description of the Course

This paper is a description of a course in the systematic qualitative analysis of a solution for cations. The course was given by the author for several years at Valparaiso University and has been given at Roosevelt College since the college was founded in the fall of 1945.

The scheme of analysis is a modification of one of the many H_2S schemes. It was first derived from the procedures of Arthur and Smith. Its difference lies mainly in that it provides for a quantitative report for each cation present.

The idea of quantitative reports in connection with qualitative analysis is by no means a new one but our method of handling them does appear to be new.

All unknowns are one per cent cation solutions. That is to say the total weight of the cations present is one per cent of the weight of the solution. Each solution has the concentration that would result if one gram of an alloy were dissolved in an acid and diluted to 100 ml.

It is important to note here that the concentration of the solution is not proportional to the number of cations present, as is recommended by many text book writers. By the method we recommend if several cations are present the concentration of each is lowered.

The student is given a 5-10 ml. sample of the unknown solution. He is directed to take exactly 1.0 ml of this solution as the basis for his analysis. This is usually measured with a pipet but a 10 ml. graduate is accurate enough if carefully used. The student is assured that this 1.0 ml. sample of the unknown contains just 10 mg. of total cations, certainly within the limits of 9.5 to 10.5 mg.

Furthermore, the student is assured that if more than one cation is present each will appear in even mg. units. For instance, one ml. of a solution containing Cu and Zn might contain 9 mg. of Cu and 1 mg. of Zn, or 8 mg. of Cu and 2 mg. of Zn, etc., but no quantities that would have to be expressed in fractions of mgs. per ml. This is the source of our title, "Quantized Qualitative Analysis." The different cations appear only in quanta without fractions just as radiant energy does.

Establishing this quanta rule is analagous to asking an analyst to find the major components in an alloy and determine the percentage present to within ten percent of the total. Any component making up less than about five percent of the total would be disregarded. It may also be considered as quantitative analysis to one significant figure.

The grade the student gets depends on how closely he comes in his report to the correct quantitative composition of the solution he analyzed. At first it might appear that this would involve too much concern on the part of the student and too great a burden in grading the reports. Actually neither of these things is true.

Consider a set of unknowns in the copper subgroup and some possible student reports on them:

Solutions	Cations					
	Hg	Pb	Bi	Cu	Cd	Grade
Unknown 1	0	50	0	50	0	
Report 1a	..	60	..	40	..	50+40=90
Report 1b	10	30	20	40	..	30+40=70
Report 1c	..	10	..	90	..	10+50=60
Unknown 2	20	30	30	10	10	
Report 2a	0	50	50	0	0	30+30=60
Report 2b	30	20	10	20	20	20+20+10+10+10=70
Report 2c	30	0	0	40	30	20+10+10=40

This system of grading has several characteristics.

(1) It is easy to use. The grade is obtained by comparing the composition and the report and adding together the smaller of the two figures appearing under each cation.

(2) Reporting ions not present or reporting them in excessive amounts is automatically penalized because then the student cannot report high enough percentages for the ions actually present. (See report 1b.)

(3) A student will get a fair mark if the qualitative part of his work is correct even though he misses the quantitative answer beyond all expectation. (See Reports 1c and 2b.)

(4) A student is not penalized so much for missing the minor components as for missing those present in large amounts. (See Reports 2a and 2c.)

The preparation of the unknown solution is a simple matter. Stock solutions of salts of the usual 24 cations are prepared. In each solution the concentration of the cation is one per cent (or 10 mg/ml). If the unknown is to contain only one cation, this stock solution also serves as the unknown. Other kinds of unknowns are made by mixing these stock solutions in the proper proportions without otherwise diluting them. For instance, a solution containing 4 mg. of Cu and 6 mg. of Zn per ml. would be made by mixing 4 ml. of the Cu stock solution with 6 ml. of the Zn stock solution. If a large number of unknowns are to be issued, it may be desirable to prepare more concentrated stock solutions from which the above mentioned dilute stock solutions can be prepared. Most soluble salts are soluble to the extent of 100 mg. of the cation per ml., but a few become saturated at a much lower concentration.

Some Details of the Analysis

To perform the analysis the student first makes the usual qualitative separations using standard semi-micro techniques. When a given cation has been isolated one of several different quantitative techniques is applied. Most of these involve comparison with standard solutions. These standard solutions are prepared by diluting the stock solutions referred to above by a ratio of 10 to 1. Thus the student always has access to a stock solution of each cation containing 1.0 mg. of the cation per ml., the minimum amount of that cation that could be present

in each unknown. If a large amount of the cation is present in the unknown, the amount will be a simple multiple of the amount in the standard.

The most common but most unsatisfactory method of estimating amounts is by comparison of precipitate volumes. Eleven of the 24 cations are handled in this fashion. They are Bi, Cd, As, Sb, Sn, Al, Zn, Ni, Mg, Na, K. For each of these that may be found present one mg. of the cation from one ml. of the stock is converted to the same precipitated compound as occurs in the course of analysis and the volumes of the two precipitates compared, usually after centrifuging. Some consideration has been given to the use of graduated centrifuge tubes but these have not been tried.

Amounts of Ag and Hg are estimated by nephelometry. For estimates to the first significant figure this does not require any special apparatus. The procedure is very simple. A 250 ml. beaker for the standard and a beaker of the same size for the unknown are placed over some reading matter. 200 ml. of distilled water is placed in each. The precipitating reagent is added to each beaker in equal amounts and a solution of the isolated cation is added to the unknown beaker. As soon as the fogginess produced by the precipitate has reached a maximum the standard solution is added to the standard beaker from a 10 ml. graduate, in 1 ml. units. The fogginess in the two beakers is compared by attempting to read the print through them. When enough standard has been added to match the fogginess of the unknown the volume of standard solution required is read from the graduate. This volume in ml. equals the number of mgs. of the cation in one ml. of the unknown solution.

Amounts of Cu, Cr, Mn, and Fe ions are estimated by measuring the intensity of the color produced by some form of the ion. Here again no special equipment is used. The volume of isolated cation solution which matches one ml. of the standard equals the number of mgs. of that cation in one ml. of the unknown.

The amount of Pb, Ba, or Sr is estimated by separating or precipitating it as a chromate, washing out the excess chromate reagent, dissolving the precipitate in HCl, and comparing the color formed with that produced in the same way from a one mg. standard.

Determining the amount of Co gives an opportunity to illustrate volumetric precipitation as a quantitative analysis technique. The Co is precipitated by alpha-nitroso-beta-naphthol and the number of drops of reagent required to complete the precipitation is determined. Three drops of the reagent precipitates 0.10 mg. of Co (not 1.0 mg.). This means 300 drops would be required to precipitate the maximum amount of cobalt that could be present. Therefore one-tenth of the isolated cation is tested. This requires from 3 to 30 drops. This illustrates the point that some tests are so sensitive that practical estimates in a reasonable time or reasonable volume can be made only by diluting the cation after it is isolated. Such dilutions are required in estimating Mn, Co, and Ni.

Ca is readily determined by an adaptation of the standard procedure in volumetric analysis where CaC_2O_4 is oxidized with $KMnO_4$. Of course, a sufficiently accurate estimate may be obtained by counting the drops of N/3 $KMnO_4$ solution required. As before from 3 to 30 drops will be used.

The amount of ammonium ion is readily obtained by treating one ml.

of the original solution with NaOH and distilling the NH_3 into cold water very much like the procedure in a semi-micro Kjeldahl determination. The number of drops of an HCl solution required to keep the distillate acidified is determined.

Some Reasons for Making Quantitative Reports

Nothing has been said thus far about the reasons for requiring students to make quantitative estimations in conjunction with qualitative analysis.

In the first place, if a student does not estimate quantities he too easily gets the impression that concentration has nothing to do with qualitative analysis, that it is possible to list all conceivable components as being simply "present" or "absent" in a given mixture. To be sure, the teacher who makes up the unknowns knows that the concentrations have to be watched rather carefully, but too often this information is withheld from the student.

Furthermore, it is usually customary to emphasize the principles of chemical equilibrium in the theoretical part of a course in qualitative analysis. Numerical calculations involving solubilities, solubility products, and ionization constants take up much of the time of the course. Most of the value of these calculations is lost if an attempt is made to apply them to solutions of unknown concentration. Likewise the typical student of qualitative analysis will have had only one or two semesters to practice calculations based on balanced chemical equations. He cannot get too much practice in quantitative thinking.

Reasons for Using One Percent Solutions

Some textbook writers recommend that stock solutions be made to a specified normality. To be sure this makes it easy to calculate equivalent quantities of reagents but it is completely unrealistic since it is obviously impossible for a practicing analyst to prepare an unknown solution so it will have a specified normality. However, an analyst faced with the problem of studying an unknown metal or alloy can prepare a one percent solution of this substance and that would seem to be the intelligent way to attack the problem.

The concentration recommended here, one percent total cations, is somewhat more dilute than is commonly used in semi-micro qualitative analysis but it gives good results. In normalities it gives a range of about 0.01 normal to 0.1 normal. It has proved advantageous to conduct many of the separations by adding 1.0 ml. of a 1.0 N solution of the required reagent. It will be seen that this is from ten to a hundred times the equivalent amount, yet the reagent itself is so dilute that a large excess does no harm to the solution. Thus it is often possible to eliminate time consuming procedures that require the student to add a reagent drop by drop until a reaction is complete.

Adjusting the acidity before precipitating the first sulfide group is a simple matter in one percent solutions. One ml. of the solution is diluted to 3 ml. and made neutral to litmus. Adding 1.0 ml. of 1 ON HCl makes the solution about 0.25 N acid, a good condition for precipitating this group. The total concentration

of the cations to be precipitated is so small that any reaction involving them has no important effect on the hydrogen ion concentration.

Summary

It is strongly recommended that students in qualitative analysis should be required to report the concentration of each cation found to the nearest mg. per ml. and that each liquid unknown supplied to him should have a total cation concentration of one percent (or 10 mg. per ml.).

This gives the student a more realistic situation to deal with, makes it possible to grade his report more fairly, and provides for better application of the theory usually taught in conjunction with such a course.

A METHOD FOR RECALLING THE CONFIGURATIONS OF THE ALDOHEXOSES

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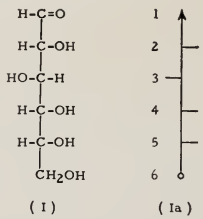
The use of mnemonics has been called upon to assist in remembering the projection formulas and, consequently, the configurations of the aldohexoses. Two words, *gam* and *gat,* formed from the first letters of the names of the six sugars; galactose, allose, mannose, gulose, altrose and talose aid in reproducing their structures. In order to use this system of memory aid, a student must know the structure of the open chain form of *d*-glucose and the names of the other sugars.

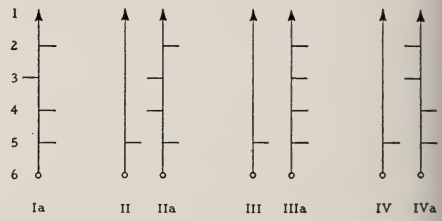
The method of reproducing the structures of the sugars is as follows: The projection formula for *d*-glucose is drawn (I) and from it is obtained a simpler method of representation (Ia) where the vertical line indicates the carbon chain, the arrow the aldehyde group, the circle the hydroxymethylene group and the short, horizontal lines the secondary hydroxyl groups. The *d*- or *l*-configuration of a carbon atom is indicated by placing



the horizontal line to the right or left of the vertical line, respectively.

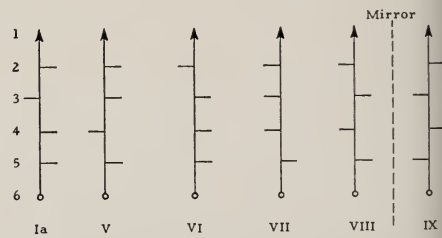
The configuration at carbon atom five in an aldohexose determines whether a sugar belongs to the *d* or *l*-series, therefore, molecule Ia must be of the *d*-form. Since the sugars under consideration exist in eight *dl* pairs, a knowledge of the projection formulas of the *d*-forms is sufficient. Therefore the horizontal line at carbon atom five will be on the right in all eight forms.

To obtain the three sugars from the word *gam,* the figures II, III and IV are drawn.



By interchanging the substituents of *d*-glucose (Ia) at carbon atoms 4, 3, and 2 in that order and keeping the configuration at carbon 5 constant, the skeletal structures IIa, IIIa and IVa, corresponding to *d*-galactose, *d*-allose and *d*-mannose, are obtained.

Using form II, the skelton form of *d*-glucose and the mnemonic, *gat,* it is easy to reproduce the structures for the next three aldohexoses.



Interchanging the groups at carbon atoms 4 and 3 in *d*-glucose yields *d*-gulose (V); at carbon atoms 3 and 2, *d*-altrose (VI); and at carbons 4 and 2, *d*-talose (VII). (In the two dimensional drawing the transference is represented by mov-

ing the short horizontal lines from one side of the vertical line to the other.)

The structures of *d*-allose and *d*-altrose should not be confused, since the former occurs first in the derivation from *d*-glucose, and is first alphabetically. The same reasoning applies to *d*-galactose and *d*-gulose.

The eight *h*-isomer of the *d*-configuration is *d*-idose (VIIIa), and while it does not fit in the mnemonic words, it is easy to reproduce from *d*-glucose by changing the configurations of carbon atoms 4, 3 and 2 simultaneously.

It is well-known that the *l*-configuration of any sugar can be obtained by drawing the mirror image of the *d*-structure. Therefore, IX, the mirror image of VIII is *l*-idose.

Summary. A new system for recalling the configurations of the sixteen isomeric aldohexoses has been devised as well as a method for drawing their structures.

GEOGRAPHY

OCCUPANCE OF THE MORAINE BORDER OF NORTHERN ILLINOIS

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The Terrain

Between the valleys of the Fox on the east and the Rock on the west lies the Moraine Border district of northern Illinois. North of the upper Illinois Valley, which forms the southern limit of the district, the crescentic recessional moraines of Wisconsin glaciation converge and give to the area a pleasing rolling surface which is quite in contrast to the flat terrain of the Grand Prairie south of the Illinois valley. The broad Valparaiso moraine enters the district from the east, the Bloomington moraine dominates the central portion, and the pre-Bloomington till extends westward toward the Rock Valley terminating in the White-Rock moraine (fig. 1).

Physiographically the northeastern portion of the district lies within the Wheaton Morainal country, the southeast is a part of the Kankakee Plain, the northwest is a part of the Rock River Hill country, and the remaining central and southwest is the northern portion of the Bloomington Ridged Plain into which extends an arm of the Green River Lowland.[1]

Prairie, interrupted at intervals by prairie groves, originally dominated the southern and western portions of the area; whereas to the north and east it was covered by an extensive series of hard wood deciduous forests. Like the Grand Prairie the wooded areas occupied the better drained lands, especially those in the drainage basins of the streams. Poorly drained uplands and extensive swails and sloughs on the featureless ground moraine plains created a drainage problem in this district almost as great as that of the Grand Prairie. Drainage ditches and field tile have transformed most of the wet areas into productive farm land leaving only local names of sloughs and prairies as reminders of the early poorly drained countryside.

Although three major streams, the Rock, Fox, and Illinois, form three sides, the district consists of two drainage areas, the Northern and Southern sections (fig. 1). The Northern section is chiefly the irregular drainage basin of the north and south branches of the Kishwaukee, which flows westward into the Rock. The tributaries of the Fox are very short and, with the exceptions of the lake region in the northeast, are of no significance to the Northern section. The Southern section is tributary to the Illinois, the major feature of which is the lower Fox River.

Cultural Patterns

Upon the terrain has been developed a variety of occupance patterns all of which are rural and agrarian. The variety and arrangement of the patterns are such, however, that the

[1] M. M. Leighton, Geo. E. Ekblaw, and Leland Horberg. "Physiographic Divisions of Illinois," *The Journal of Geology*, Vol. 56, No. 1, January, 1948.

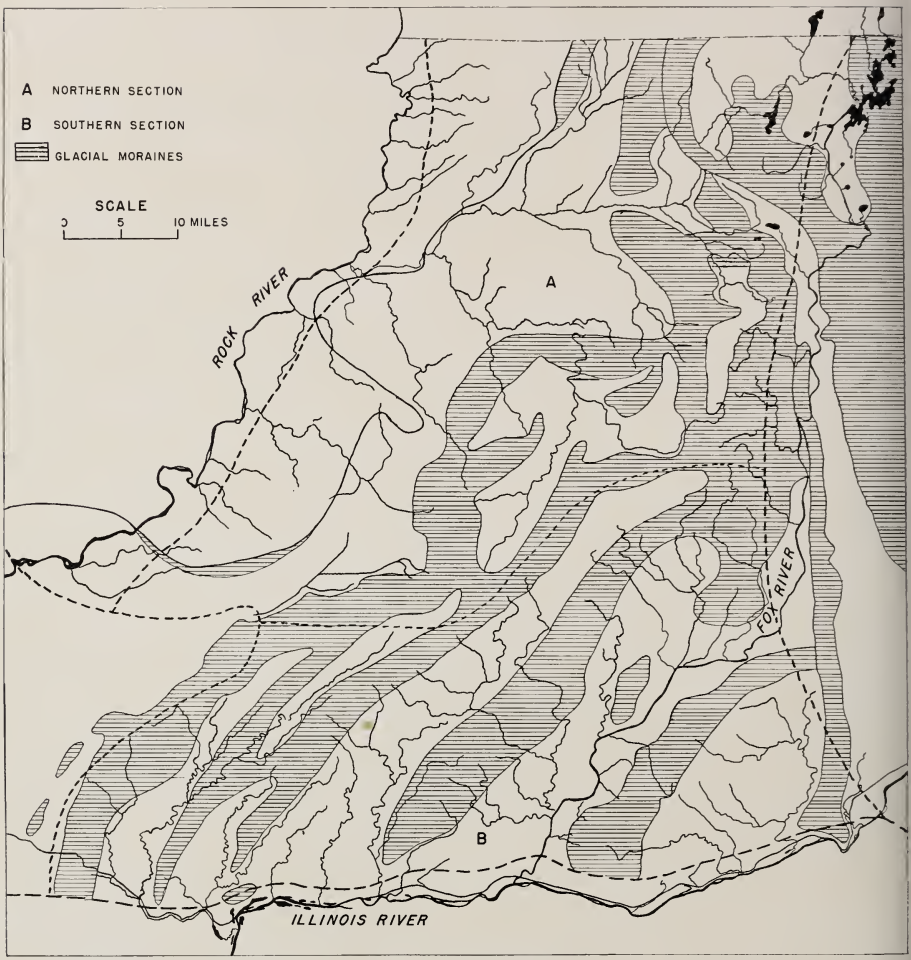

Fig. 1.—Physical patterns of the Moraine Border district.

section is actually a land of transition.

Settlements

Although the bordering valleys are zones of urbanization, the Moraine Border district is a land of towns and villages and evenly spread farmsteads. There are only 140 incorporated towns and cities in the entire district which includes parts of 12 counties (fig. 2). Of that number there are only ten large enough to be within the city classification of 2,500. Seven of these are in the Northern section and three in the Southern. Of the ten the two largest are DeKalb and Belvidere. In the Census of 1940 their respective populations were 9,146 and 8,094 although recent estimates place them at 12,150 and 10,051. Four of the ten cities, Belvidere, Woodstock, Sycamore, and Princeton, are county seats. With the exception of DeKalb and Sycamore,

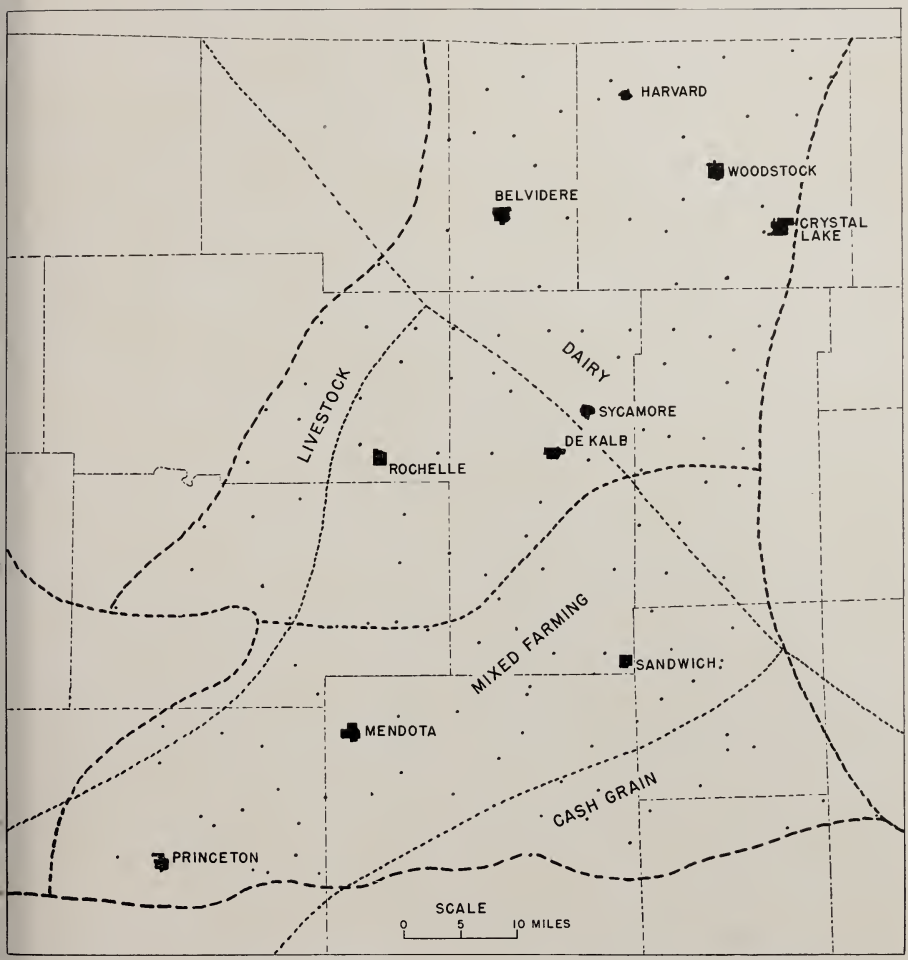

Fig. 2.—Occupance patterns of the Moraine Border district.

which are about seven miles apart, the cities are well spaced indicating a basic agrarian service center function. It is well to note that DeKalb, the largest city, is the most industrial of all. The fact that the county court house is in Sycamore and the Northern Illinois State College is in DeKalb, a short distance away, indicates some of the rivalry arising from urban spacing.

The towns and villages are aligned at five to eight mile intervals in a general east-west orientation. This obviously is due to the railroad net which in general extends across the district as a series of lines radiating from the Chicago metropolitan district. Pre-railroad settlements reached by the railroads grew, whereas the rest disappeared with time as the post-railroad pattern of settlements crystallized. Only two railroads extend across the district in a north-south trend and they are small freight lines.

The original county and township survey gave to the district the traditional checkerboard of section-line roads. Right of travel altered some of them, and the lack of surfacing material obliterated many more. With the development of the automobile, the truck, and the bus, national and state hard-surfaced highways were projected through the district, both from east to west and south to north. Although local interests were desirous of perpetuating the pattern by routing the concrete highways through the small villages, the undesirability of routing fast traffic through villages has been demonstrated both as far as the traffic and the individual settlement is concerned. Thus patterns are being developed to by-pass villages by a short enough distance that neither the traffic nor the village is inconvenienced.

Agricultural Patterns

Although dominantly rural and agrarian, the Moraine Border district is a land of transition as far as farming types are concerned. Three critical farming type boundaries cross the district dividing it into four distinct areas.[2]

The first farm type boundary is the western limit of the dairy belt which divides the district from northwest to southeast. Within the northeastern part of the dairy landscape is outstanding. Modern dairy barns and silos, herds of Holstein cows, well-fenced pastures, and fields of fodder are the agrarian occupance features of the rolling morainal land. Dairy farms are large, well-painted, well-kept and imposing in appearance, and most exacting in requirements.

The towns and villages are collecting centers, in some of them are dairy plants belonging to organizations located in the Chicago metropolitan district toward which the fresh milk moves daily. Collectors truck the raw milk in cans from the dairy farms to collecting stations from which glass-lined tank trucks and trains continue it citywards. The railroad is no longer as important as it once was when each of the several railroads radiating out through the milk producing region ran at least one slow express daily, known as the milk train, for the purpose of transporting milk to the metropolitan district.

Distance, no doubt, is an important factor in crystallizing this particular pattern of occupance. Natural environmental conditions, although advantageous within the dairy farming zone, do not change markedly at the dairy boundary which has remained constant for years. It is well to note that dairy farming, although the finest type of agrarian adjustment, is highly specialized, the equipment is enormous and expensive, and a fine dairy herd capable of demanding highest returns is not easy to build up. Thus the area has crystallized as a dominant occupance feature of the Moraine Border district.

Near the western edge of the district, approximately at the boundary of the Wisconsin drift, is the boundary of mixed livestock farming. Beef cattle, hog, and dairy farm, especially those selling to creameries, dominate the area. Although the crops in the fields are essentially the same over the entire Moraine Border district consisting of corn, small grain, hay and pasture, the commercial aspects are quite different. Distance from the Chicago metropolitan district is the significant factor. Loading chutes along the railroad in the villages and livestock trucks on the highway take the place of the daily milk truck.

[2] H. C. M. Case and K. H. Meyer, Types of Farming in Illinois. Univ. of Ill. Agr. Exp. Sta., Bull. 403, June 1934.

The infrequence with which stock beef cattle, fat hogs, or even cans of cream are marketed is a vital factor. On the other hand the rolling terrain is a significant pasture land.

The southeastern part of the district, especially the area between the Fox and Illinois rivers is a land of cash grain farming similar to the Grand Prairie south of the Illinois Valley. The deep black soil of the Kankakee plain is utilized as only the richest of soil can be for commercial grain farming. There the grain elevators are large, the barns are small, and grain is trucked to market.

Between the livestock farming on the northwest and the cash grain farming on the southeast is a broad transition zone of both livestock and grain farming extending southwestward from the dairy boundary. In the same manner trend the recessional moraines of Wisconsin glaciation, the Bloomington, Cropsey, and Farm Ridge moraines, separated by extensive elongated areas of poorly drained ground moraine. Thus, beyond the limits of profitable dairy marketing, the morainal ridges and interspersed plains are the sites of both livestock and cash grain farming.

Here both stock loading pens and grain elevators line the railroads in the little agricultural villages and livestock trucks traverse the highways. Although this portion of the Moraine Border district is too far from the Chicago metropolitan district for the daily shipment of fresh milk, it is the nearest area to the world's largest stock yards for the periodic delivery of live hogs, sheep, and cattle. The extent to which portions of the district have been used to fatten cattle and western sheep is notable. The large sheep feeding yards are no longer as important as they once were and some have disappeared entirely. It was within this portion of the district that a part of the government-sponsored wartime hemp growing was centered.

Industrial Patterns

In an agrarian structure such as that of the Moraine Border district, industry is of little significance. Here the major features are in keeping with the agricultural background which the towns and villages serve. Canning factories account for the most widespread manufacturing activity of the district. Corn, peas, lima beans, tomatoes, pumpkins, and asparagus are among the vegetables packed by the canning companies which are most important in the Northern section especially in the larger towns. Belvidere, Marengo, Sycamore, and Rochelle are the significant canning factory towns. Although the canning activities are limited to the summer season, causing a marked labor problem, vegetable growing is carried on chiefly on farms owned outright or leased for terms of years by the canning companies.

Among the industries of the district designed to use or to prepare perishable agricultural produce for market are the dairies and creameries in the towns and villages, especially in the dairy farming portion of the district. Similarly the hemp mills of the war period were constructed to process hemp fibers. Government mills were constructed near Earlville, Shabbona, and Kirkland.[3] Since the close of the war, these factories have been closed, offered for sale, and at least one has been converted to other industrial purposes.

At an early date small shops and factories making farm machinery

[3] John H. Garland, "Hemp—A Minor American Fiber Crop," *Economic Geography*, Vol. 22, No. 2, April, 1946.

and other equipment for the agricultural countryside were widespread. Today most of these have disappeared as farm machinery manufacturing has become standardized and centralized in a few large companies. A few agricultural service manufacturers as well as those depending on a general market have developed in the large towns and cities. Notable among these are the manufacture of milking machines and dairy farm equipment at Harvard and Deisel engines at Rochelle, whereas machine shops that make parts for farm machinery are widespread. The invention of barbed wire at DeKalb and the development and operation of the American Steel and Wire Company there for a number of years gave to the largest city of the district the most industrial atmosphere. In a like manner the manufacture of sewing machines is outstanding in Belvidere, the second largest city. DeKalb was selected during the war for the site of an airplane factory.

Many other items such as telephone parts, electrical switches, cardboard boxes, dry cleaning machinery, furniture, barber's tools, yarn, typewriters, and the like are made in small factories in many of the towns and cities. The manufacture of nationally advertised pianos at DeKalb is one of the industries in which central position within the national market is significant.

Although there are shreds of evidence that light industries are interested in and are actually moving towards the towns and villages of the countryside which lies between the Rock River, Fox and Illinois valley industrial districts, the dominant note of the Moraine Border district is one of agricultural transition which occupies a rolling terrain of variable glacial features.

GEOLOGY

COAL RESOURCES OF FRANKLIN COUNTY, ILLINOIS*

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State Geological Survey, Urbana

Franklin County, Illinois, is unique as a coal producing area in several ways: It is the only coal producing county in the State which at the start of the century had produced no coal and contained no coal mines. In 1946, however, this county produced more coal than any other county in the State—14,470,904 tons or 23 percent of the total State production for that year. Its average production per mine in 1946 of 1,113,146 tons was exceeded only by Christian County where five mines produced an average of 1,279,882 tons. One mine in Franklin County attained the highest output in the State of 2,469,470 tons, a relative position which this mine has held for 8 years and for 20 out of 22 years prior to 1947. This same mine also holds the daily output record of the State of about 15,000 tons, a record, however, which was nearly equalled by a rival mine in the county. It had the fame, at one time at least, of being the world's largest underground coal mine. Production in Franklin County is at present in the hands of five operating companies, one mine being a captive mine owned by a railroad which takes all its production.

Franklin County originally contained what appears to have been the State's largest volume of coal with a sulphur content of less than 1.25. A considerable part of this coal contained less than 1 percent sulphur. It also contains the State's thickest known bed of coal, which is 9 to 14 feet thick over considerable areas. Franklin County has probably been more thoroughly explored by the diamond drill than any other county in the State, but exploration has not often extended below No. 5 coal bed, only thirteen holes having been drilled to the greater depth, out of more than 300 that have been drilled.

The coal mined in Franklin County is produced by fewer men per ton—8.7 tons per man day in 1946—than that produced by any other county in the State except Christian which had a rating of 11.5 tons per man day for the same year. The 1946 record in neighboring Saline County, in spite of the considerable strip-mine tonnage, was 6.5 tons per man day, and for Macoupin County 7.6 tons. Fulton County, on the other hand, where most of the coal comes from strip mines produced coal in 1946 at the rate of 21.22 tons per man day.

Many more persons are employed in the coal industry in Franklin County mines than in any other county of the State, 7,402 employees being reported for 1946. The county with the next largest mine pay roll is Macoupin with 2,693 employees.

Railroads conveying coal out of Franklin County derive an annual revenue of about 20 million dollars from this service, assuming an average freight payment of $2.00 per ton. In 1946 about 10 million tons of coal were shipped on four railroads serving the county, requiring

* Published with permission of the Chief, Illinois State Geological Survey.

200,000 fifty-ton cars, or 4,000 fifty-car trains, or an average of more than 10 such train-loads daily during 1946.

The fatality record of the mines in Franklin County has fallen from the high rate of 4.89 fatalities per million tons of coal produced between 1911 and 1919 to an average of 1.11 fatalities per million tons between 1940 and 1946. This decline, although still higher than the State average of 0.4 in 1946, which is unusually low, has been brought about in spite of a highly hazardous, natural gassy condition in these mines, largely owing to the contributions to mine safety made by one of the foremost mine safety engineers in the country and a notable citizen of the county, John E. Jones. The present methods of mine rock dusting in widespread use throughout the country are largely due to Mr. Jones' ingenuity and persistence.

Over against the numerous facts pointing to the great importance of the coal mining industry and the coal resources to this region are other facts that call for the evaluation of the permanence of this industry and the availability of the coal resources. To what extent are these resources actual reserves of wealth and prosperity?

The area of the county is relatively small. This is the 66th county in respect to size, having an area of 445 square miles (284,716 acres). Furthermore, in about 14 percent of the area or 60½ square miles (38,685 acres) the No. 6 coal bed is regarded as unworkable because the bed splits into unmineable thin parts. This leaves 384½ square miles (246,031 acres) of the county underlain by workable No. 6 coal bed, assuming that a bed less than 6 feet in thickness at depths varying from about 750 to 850 feet is workable.

There is the further consideration that vigorous mining has been underway in this county about 45 years with a total output to the end of 1946 of 399,794,122 tons.

The original supply of coal in the No. 6 coal bed has been estimated on

Table 1.—Original Coal Resources in No. 6 Coal Bed in Franklin County

	Area in acres	Percent of county	Percent of productive area	Estimate 1916 Coop. Bull 15	Estimate 1934	Estimate 1948	Percent
				Millions of tons			
Split coal area	38,685	14	.....	.....	.....	.....	.....
Coal more than 8 ft. thick (Av. 9 ft. assumed)	113,970	40	47	.....	.....	1,814	54
Coal 6-8 ft. thick (Av. 7 ft. assumed)	92,162	32	37	.....	.....	1,142	34
Coal under 6 ft. (Av. 6 ft. assumed)	39,962	14	16	.....	.....	424	12
Total	284,716	.....	.....	3,718	3,282	3,381	.....

various bases from time to time (table 1) and appears to be about 3 1/3 billion tons, of which 424 million tons or 12 percent is probably less than 6 feet thick, 1,142 million tons or 34 percent is between 6 and 8 feet thick, and 1,814 million tons or 54 percent was more than 8 feet thick.

A total of 30 percent of the area underlain by No. 6 coal bed in the county, exclusive of the split-coal area (table 2) (73,454 acres or 114.8 square miles) has been mined out or rendered unmineable (fig. 1) and this area contains essentially all the coal with less than 1 percent sulphur content and much of that with less than 1.25 percent sulphur.

Most of the remaining supply of No. 6 coal bed lies in the eastern half of the county, and only two of the existing mines are probably so situated that they can mine the coal in this area within reasonable limits of cost. It is also significant that several mining ventures in the northeast part of the county north of or along the Illinois Central Railroad from Benton southeastward, found it impossible to maintain production in competition with the more favorable conditions in the mines in the western part of the county.

In spite of the evident realization on the part of the coal mining industry of the approaching depletion of the better and thicker portions of No. 6 coal bed in the western side of the county, no new mining ventures, as indicated by advanced drilling, seem to be underway in the northeastern part of the county.

In this connection attention may well be called to what appears to be an area of relatively thick coal north of Logan and in the vicinity of Bessie in an area traversed almost down the center by a branch of the Illinois Central Railroad running from the vicinity of Akin to West Frankfort (fig. 1). The position of the area is also indicated on Fig. 2 as an area where the thickness of the interval between the No. 6 coal and the first limestone is more than 10 feet. Additional drilling is necessary to prove the area but it seems to hold promise of being the only tract north of the Illinois Central Railroad branch to Eldorado in eastern Franklin Coun-

Table 2.—Data on Depletion of No. 6 Coal Bed in Franklin County

	Acres	Sq. Miles
Total mineable area	246,013	384.4
(Excluding split coal: 14% of county)		
Mined out area:		
A. Actual (25%)	61,649	96.3
B. Including barriers (30%)	73,454	114.8
Total production in tons (to date of mine maps)	385,401,214 tons	
Production in tons per acre:		
A. Actual mined-out area	6,252 tons	
B. Including barriers	5,247 tons	
Thickness of coal removed (in feet):		
A. Actual mined-out area	3.53 feet	
B. Including barriers	2.96 feet	
Percentage of coal removed:		
A. Actual mined-out area		
1. 9 ft. assumed average thickness	39 percent	
2. 8½ ft. assumed average thickness	42 percent	
B. Including barriers		
1. 9 ft. assumed average thickness	33 percent	
2. 8½ ft. assumed average thickness	35 percent	

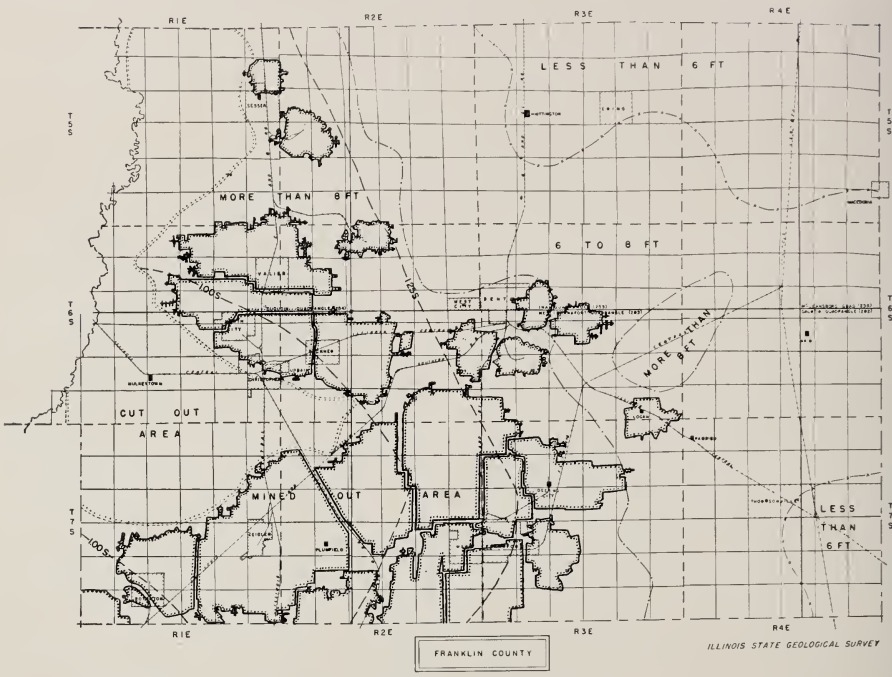

FIG. 1.—Map of Franklin County showing mined-out areas, "cut-out" area, areas in which sulphur content of No. 6 coal bed is less than 1.0 percent, between 1.0 and 1.25 percent, and greater than 1.25 percent; and areas in which No. 6 coal bed is less than 6 feet, between 6 and 8 feet, and more than 8 feet thick.

ty where there are attractive possibilities from the viewpoint of present mining requirements.

In connection with the depletion of resources in No. 6 coal bed in western Franklin County the character of recovery is of interest. The prevailing idea concerning the recovery as expressed by most engineers in the area is that this amounts to about 7,000 tons per acre. Assuming a weight for the coal of 1770 tons per acre foot (a figure long used by the State Geological Survey in coal resource studies) the recovery is equivalent to a bed almost exactly 4 feet thick (7080 tons). This recovery has been in an area where the thickness of the No. 6 bed exceeds eight feet and not infrequently is 10 feet. It seems, therefore, even on the basis of the commonly accepted figure of 7,000 tons per acre that the recovery is less than 50 percent.

Planimeter measurements of the mined-out area indicated on a small scale map (fig. 1) show that the total production of 385,401,214 tons (up to the date of the mine maps) had been taken from a mined-out area of 61,650 acres. This represents an average recovery of about 6,250 tons per acre (table 2), rather than 7,000 tons.

Recovery is not uniform in different parts of the county. Consider the three separate, more or less individually continuous areas, one in the south part of the county, one in the north part (but not including the detached mines near Sesser), and one in the eastern part (but not including the mine at Logan). The recovery (table 3) in the mined-

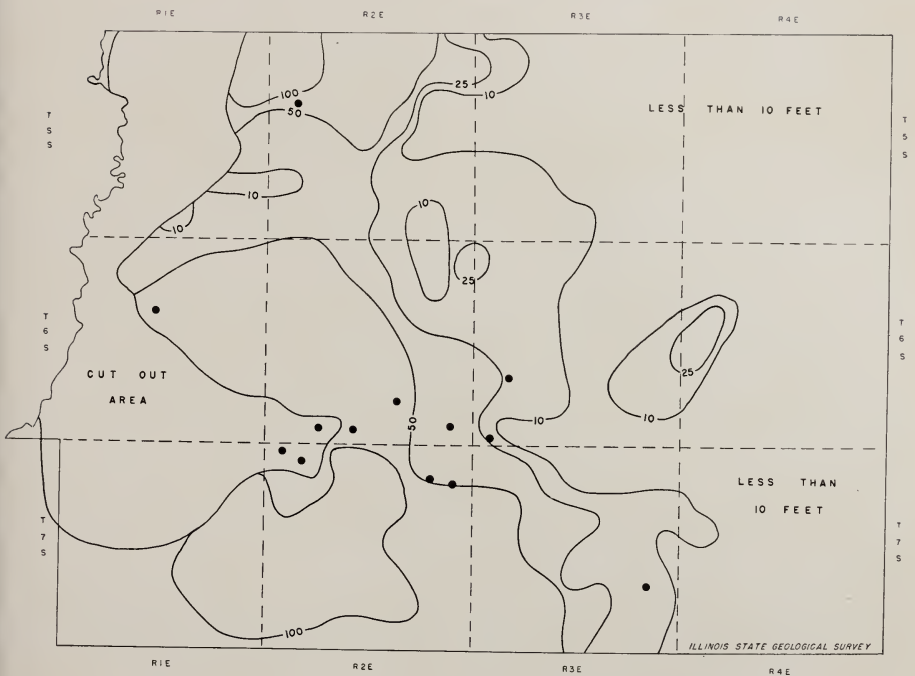

FIG. 2.—Map of Franklin County showing the distribution of variations in the interval between No. 6 coal bed and the first limestone above this coal bed, (10, 25, 50, and 100 feet) and the location of diamond-drill holes extending below No. 5 coal bed.

TABLE 3.—STUDY OF DEPLETION IN THREE SELECTED MINED-OUT AREAS IN FRANKLIN COUNTY

	Area in acres	Total production in thousands of tons	Production in tons per acre	Coal removed (feet)
North Tract				
Actual mined-out area.....	13,356	85,745	6,420	3.63
Including barriers.....	16,300	85,745	5,267	2.98
South Tract				
Actual mined-out area.....	41,228	265,577	6,442	3.64
Including barriers.....	48,000	265,577	5,533	3.12
East Tract				
Actual mined-out area.....	3,411	17,275	5,064	2.86
Including barriers.....	5,500	17,275	3,141	1.77

out southern part is at the rate of 3.64 feet, in the northern tract essentially the same, but in the eastern area is only 2.86. These figures refer only to the actual mined-out area as bounded by the extreme face. If the total area is considered, barrier pillars, town site reserves, railroad right-of-way pillars and unmined irregularities such as those along the margin of the split coal area, the figures are smaller, being 3.12 feet for the southern area, 2.98 for the northern area, and 1.77 feet for the eastern area where abandonment of the mines will undoubtedly result in high barrier-pillar loss marginal to any new operations.

The character and thickness of the No. 6 coal bed bears a definite although not fully understood relationship to the black shale and limestone caprock. Wherever the coal bed is separated from the black shale by less than about 10 feet of strata (usually by gray shale) the coal bed is rarely more than about 8 feet thick and commonly not more than 6 feet thick. The thin coal bed is characterized by a high sulphur content, usually more than 2 percent. The critical relationship, however, is not that of thickness of bed but one apparently involving the proximity of the black shale. Because of this very definite and well substantiated relationship it seems probable that the thin No. 6 coal bed in the eastern and northeastern part of the county, where the black shale and limestone lie close above the coal bed, will have a relatively high sulphur content from which it will probably be difficult but perhaps not impossible to produce the same high quality fuel as has been shipped out of Franklin County for many years.

There is at least one other matter that affects the volume of coal reserves to some extent. It is regarded as good practice to guard oil test holes by at least a 100-foot pillar, that is by a pillar not less than 200 feet in diameter. Where pools have developed in a mining area the mines and position of the drill holes are usually so planned as to reduce to a minimum the extra loss involved in an oversize pillar for an oil well or test hole. Where wells are drilled in abandoned mines or abandoned parts of mines no extra loss of coal is involved unless the well or wells get out of hand in the mine and cause disruption of mining and loss of coal or even of the mine. In the case of wildcat wells or drill-holes or where pools consist of only a few wells some loss of coal may be expected, particularly if uncertainty exists in regard to the character of the plugging. In such a case it is advisable to provide a 200-foot rather than a 100-foot pillar around the drill-hole. A 100-foot pillar contains about 1277 tons per foot of coal or about 10,000 tons for an 8-foot bed. A 200-foot pillar would contain about three times as much. There are, up to date, in the order of 75 to 100 oil test holes in the largely undeveloped eastern half of the county (fig. 3).

Brief consideration may now be given to the resources present in Franklin County in beds other than No. 6. Of these coal No. 5 (fig. 4) which lies from 30 to about 100 feet below coal No. 6 is the most important and most widespread. Its continuity is probably somewhat greater than that of No. 6 since it appears to be present under at least part of the "split-coal" area although to what extent is not well known. In general No. 5 bed is 3 to 4 feet thick, and fairly uniform in thickness. In the north part of the county there is one area where the bed is 5 feet thick, being nearly as thick as the No. 6 bed. The number of drill-holes that have penetrated to No. 5 bed is too small and the holes are too

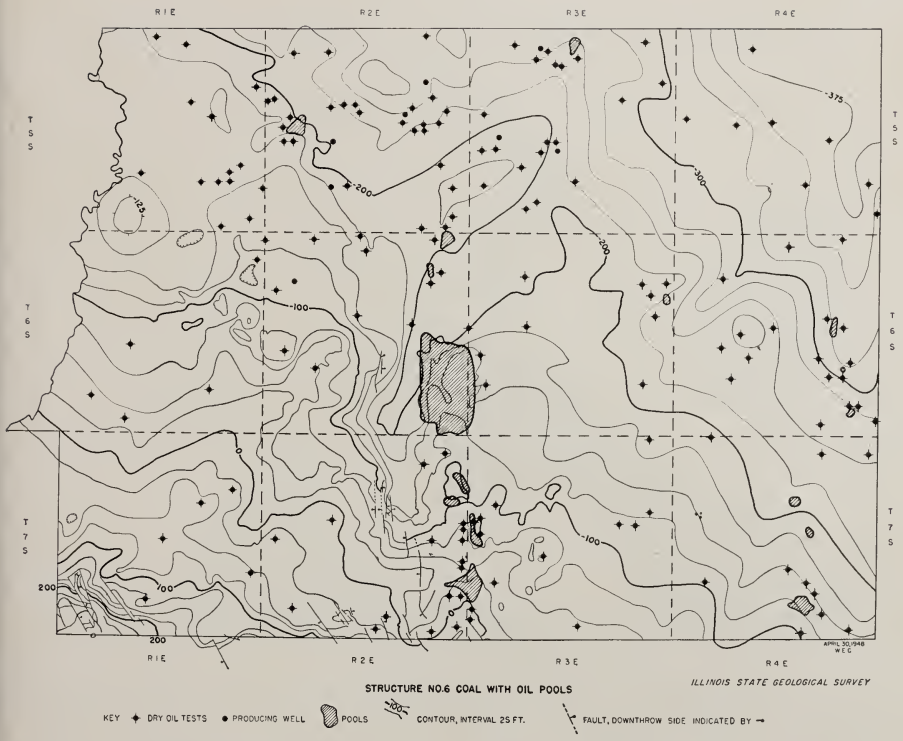

FIG. 3.—Structure of the top of No. 6 coal bed, location of oil pools, and of oil-test holes not in pools (wildcat holes).

erratically distributed to justify statements as definite in regard to the quantity of coal present in this bed as can be made in regard to No. 6 coal bed. There is particular need for more information in the northeast part of the county and in the "split-coal" area.

As a coal reserve, in the sense of a body of recoverable coal under prevailing mining conditions, the No. 5 bed has uncertain and rather doubtful value. It is very doubtful whether it can be recovered where it lies below areas of mined out No. 6 bed, particularly where the interval is less than about 50 feet. Unless mining conditions change considerably, and this possibility of course exists, the value of No. 5 coal bed as a real reserve rates low. However, in those parts of the county where the No. 6 and No. 5 bed lie 75 to 100 feet apart mining methods may be devised, as new machines become available, so that both beds can be recovered simultaneously. It seems reasonable to regard as possible the recovery of as high a proportion of the combined 10 feet of coal in the two beds as has been recovered from the single bed of the same thickness in western Franklin County. There are possibilities of improved recovery in the retreating method of mining that have not been explored but deserve trial. In any case, however, the No. 5 coal bed will probably not supply the natural premium quality of coal character-

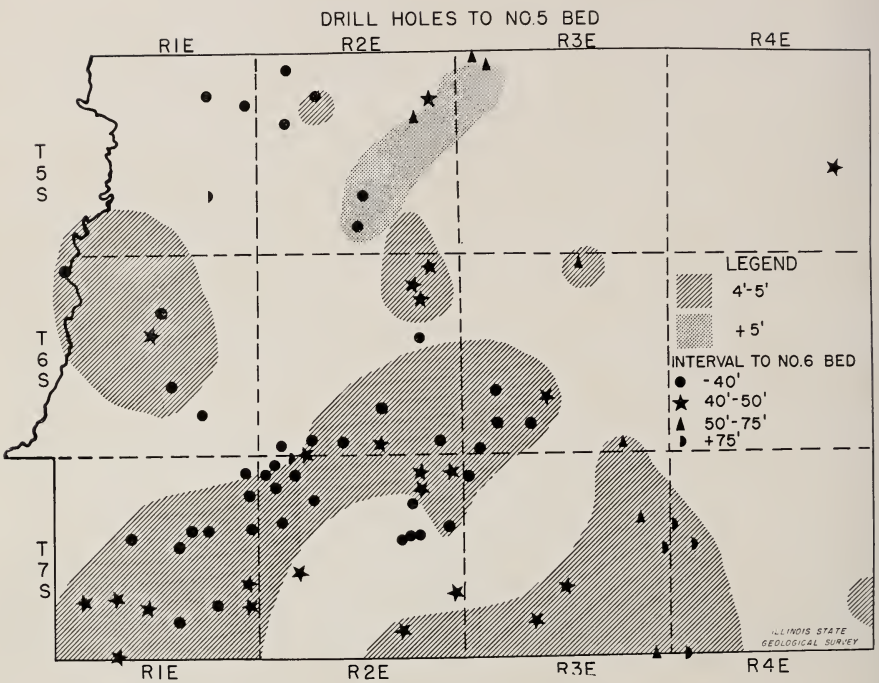

FIG. 4.—Map showing drill-holes that have penetrated No. 5 bed, distribution of variation in the thickness of the No. 5 bed, and the distribution of interval between No. 5 and No. 6 beds.

istic of the No. 6 bed where it is now being mined.

The amount of coal represented by the No. 5 coal bed in Franklin County, assuming that there are 309 square miles in which the bed averages 3½ feet thick (3 to 4 feet), 125 square miles in which it averages 4½ feet (4 to 5 feet) and 11 square miles in which it averages 5 feet (5 feet plus) is as follows:

Thickness Feet	Square Miles	Tons
3½	309	1,225,123,200
4½	125	642,297,600
5	11	63,304,000
Total		1,929,724,800

or roughly 2 billion tons. Of this 704,601,600 tons represent the coal bed where it is more than 4 feet thick. Of this area 60 square miles, in which there are 310,953,000 tons of coal, is in the area where No. 6 bed has already been mined out and the possibility of recovery of No. 5 coal is regarded by the writer as doubtful. This leaves about 400 million tons of coal thicker than 4 feet in the area where No. 6 coal has not yet been removed. Of this probably no more than about 200 million tons is recoverable, unless mining methods change considerably, which is possible.

In view of the very little information in regard to the thickness of No. 5 coal bed in the northeastern part of the county these estimates are based on an assumed thickness of 3½ feet. This estimate involves the resources in this bed for about one-quarter of the area of the county. It may be hoped that fur-

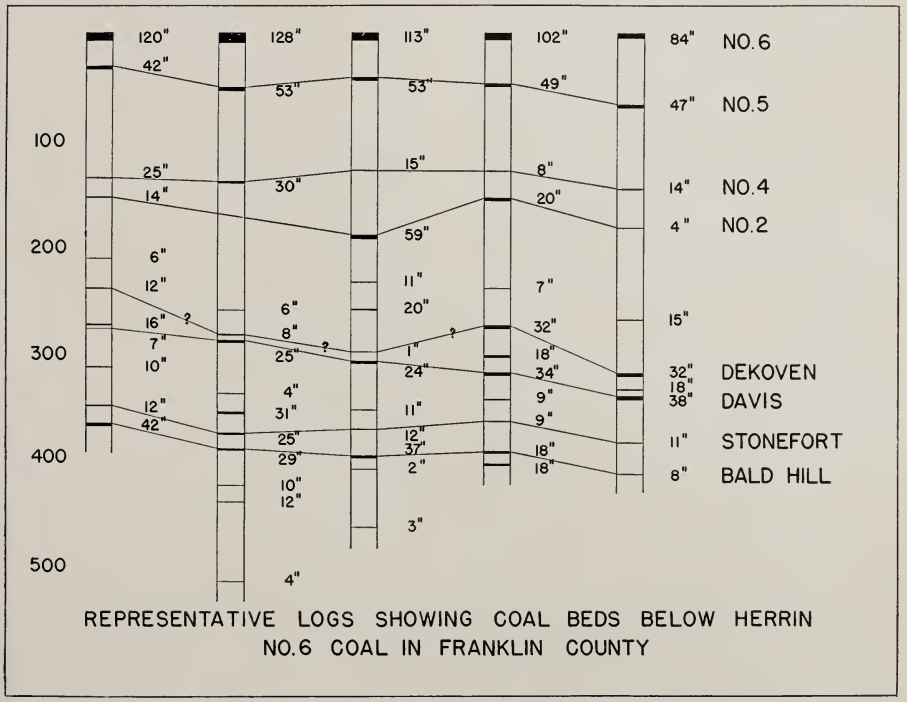

Fig. 5.—Coal beds penetrated in five selected diamond-drill holes at scattered positions in Franklin County.

ther drilling may find that this estimate is too conservative.

The coal resources of the county are not completely represented by the No. 5 and No. 6 coal beds. There are no beds exceeding about 18 inches in thickness above the No. 6 bed. The Cutler coal bed, commonly present 30 to 40 feet above the Herrin (caprock) limestone may occasionally reach 2 feet, but it is lenticular and generally unmineable. The accompanying chart (fig. 5) shows the position and thicknesses of coal beds below No. 6 bed in a group of diamond-drill holes that have been rather recently drilled here and there in the county. The amount of such deep drilling has been relatively small (fig. 2) and not scattered widely enough to provide a very satisfactory picture of the areal extent of the deep lying beds. The general conclusion that can be derived from the available information is that although occasionally coal beds 4 to 5 feet thick may be present and be penetrated in drilling, the beds are usually not thick and are characteristically lenticular and discontinuous. The two beds believed to have the widest distribution are known as the DeKoven and Davis lying between 250 and 300 feet below No. 6 bed. Even these are thin and become difficult to recognize toward the west, and even on the east side of the county are not likely to be more than 40 inches thick. The DeKoven, the upper bed of the two, is likely to be "cut out" by the overlying Palzo sandstone. The well known Murphysboro coal bed of Jackson County has not been recog-

nized with certainty among the coal beds penetrated in Franklin County. It may be either the Stonefort or Bald Hill bed. It is not the DeKoven and Davis bed as was once thought.

It is not probable that these lower coal beds will ever provide a basis for large coal mining industry such as that with which we are now familiar in Franklin County, although it cannot be said that none of these beds will ever be mined. Further drilling may discover considerable areas where one or more of these beds maintains a thickness of 4 to 5 feet. Furthermore, "ever" is a long time and man may get very desperate for fuel.

Underground gasification holds some possibility for utilizing the energy present in the thinner coal beds and in portions of the thicker beds where the quality is poor, such as in the split portions of the No. 6 coal bed. Once the No. 6 bed is entirely worked out adjacent to the "split-coal" area the development of gasification projects as a means of recovering the energy available in the split portions of the bed is a possibility that should not be overlooked. The same procedure might be applied to No. 5 and lower beds where conditions might be suitable. It is very desirable that underground gasification be tried under conditions existing in the coal fields of the middle west in order to provide a satisfactory basis for determining its applicability to these coal beds.

Conclusion

The coal resources of Franklin County may be classified into four categories: First, those resources which represent coal which can be and probably will be recovered under present conditions of mining practice and competition, the certain reserves; second, those resources represented by coal 6 to 8 feet thick which probably will be recovered, the probable reserves; third, those resources represented by a coal bed less than 6 feet thick concerning which the possibilities are doubtful. the doubtful reserves; and, finally, those resources represented by beds too thin or irregular, or both, that probably never will be worked and therefore cannot be regarded as reserves of energy or wealth.

The definite or certain reserves are represented by the approximately 897 million tons of coal in a bed 8 feet or more thick. The coal in this reserve is held very largely by two companies with a present combined output of about 10 million tons. By maintaining an unusually high rate of recovery of about 55 percent at the same annual rate of production this body of coal should last another fifty years. It is not to be expected, however, that the man power required to mine this volume of coal will continue at the present rate but that it will decrease. Accordingly the mine pay-roll in the county will undoubtedly fall from year to year partly because of the complete depletion of some of the mines and as a result of more efficient recovery in terms of tons per man day. A stepping up of the production by these two mining companies would of course tend to maintain pay-roll volume, but would shorten the life of the field.

The second category of reserves is represented by No. 6 bed where it is between 6 and 8 feet thick and by No. 5 bed where it is more than 4 feet thick. Consider No. 6 coal bed first: The probability of mining in this area containing approximately a billion and one-quarter tons of coal is affected by the absence of operating mines and the

more important unprofitable experience of companies that have undertaken such mining in the past. In general this intermediate area of the No. 6 coal bed is intermediate in other ways than in geographical position. The coal is characterized by considerable variability in quality and thickness, the sulphur content varying in short distances from relatively low to relatively high. The roof conditions provide a hazard that mining companies will hesitate to face. The interval between the coal bed and the caprock varies irregularly with lenticular bodies of gray shale commonly intervening between the coal bed and the black shale that usually lies immediately below the caprock. Cost of development will be increased by the need for more than the usual number of holes in order that irregularities may be sufficiently explored. Successful operation of this 6 to 8-foot coal bed also calls for more technical study of the roof material than has yet been applied to such rock, but considerable and possibly the best information about conditions in the area will be obtained as the mines operating in the more favored reserve area approach the margin of that area and encounter thinner coal and more irregular roof conditions. For the present at least it appears that the area of 6 to 8-foot coal should be written off as an immediate reserve, but the general thickness of the coal is such that a few improvements in mining or cleaning practice, or both, might very well throw it into the category of the immediate reserve.

With respect to No. 5 coal bed: The coal present in this bed lies in either the probable or doubtful reserves. The portion of the bed concerning which there is undoubtedly the most interest is where the bed underlies the already worked out areas of No. 6 bed because it can be reached so easily from shafts now working in the upper bed. Some of these shafts actually extend to the No. 5 bed already. It would seem as though the No. 5 bed could be worked as cheaply while operations are still active in No. 6 as after such operations cease, and failure to start such operations up to the present is not an encouraging indication of the workability of the bed.

The area of greatest promise with respect to No. 5 bed appears to be the approximately 11 square miles in the northern part of the county where the bed is more than 5 feet thick. It would seem desirable if the coal should be explored in this tract to mine both No. 6 and No. 5 beds from the same shaft. The two beds are sufficiently widely spaced and the lower coal sufficiently thick so that it might be possible to work the lower and upper beds contemporaneously in a large area in the southeastern part of the county where No. 6 coal is over 6 feet thick.

In the northeast part of the county where No. 6 coal is less than 6 feet thick both beds are 800 feet or more in depth and the coal resources in both beds rate no better than doubtful reserves although there has not been enough drilling for definite estimates.

The coal present in the beds below No. 5 coal represents a doubtful reserve. Drilling to date does not provide information sufficient to justify including such coal beds that have been encountered in either of the high categories. In certain areas there seem to be lenticular fairly thick bodies of one or more of the coal beds below coal No. 5 but no two holes seem to have penetrated coal beds as much as four feet thick at the same stratigraphic position except possibly in

the case of the Davis coal. This bed seems to be that thick only in the southeastern part of the county. It is possible that some time one or more of these beds might be found suitable for underground gasification, but it is not probable that they will be mined by shafts, except possibly in very local areas.

The present study of the status of coal resources and coal reserves in Franklin County points to the complete exhaustion of the high quality more easily mined No. 6 coal within the county in a matter of about 50 years or less. This depletion of No. 6 coal where it is more than 8 feet thick will undoubtedly be accompanied by the gradual decrease in the number of individuals supported by the mining industry in the county. It is quite possible that this decrease may take place slowly enough to cause no particular hardship. Furthermore, there is a possibility that some of the slack, should any exist, may be taken up by the start of new operations in the coal lands underlain by No. 6 bed where it is between 6 and 8 feet thick. This possibility depends a good deal upon progress made in mining methods, in improved efficiency of mining machines, in the improved understanding of the behavior of roof materials, and on improvements in mechanical devices for converting the energy in the coal into mechanical energy. Encouragement must be given to coal research in fields, such as geology, chemistry, and various branches of engineering impinging upon the coal mining industry and various aspects of coal utilization, including underground gasification.

Summary of Resource Data for No. 6 Coal Bed in Franklin County

	Acres	Percent	Square miles
The area of the county	284,716	.....	445
The "split-coal" area	38,685	14	60.5
Area exclusive of "split-coal" area	246,031	86	384.5
Area in which No. 6 coal bed has been mined or rendered unmineable	73,454	26	114.8
Total area No. 6 coal bed unavailable either mined out or in "split-coal" area	112,139	40	175.2
The available balance	172,577	60	269.8
Of the available balance area (100%)			
No. 6 coal is less than 6 feet thick in	39,962	23	62.4
No. 6 coal is 6-8 feet thick, excluding mined out area, in	90,396	52	141.2
The remaining area No. 6 more than 8 ft	42,219	25	66.0

Converted into tonnages these data signify that

The area of No. 6 less than 6 feet thick contains ..... 424,396,000 tons
The area of No. 6 between 6 and 8 feet thick contains ..... 1,125,887,000 tons
The area of No. 6 in which No. 6 coal is more than 8 feet thick, contains ..... 896,917,000 tons

No. 5 Coal Bed

The coal in No. 5 coal bed in Franklin County is approximately 2,000,000,000 tons. It ranges from a possible to a doubtful reserve.

OIL ACCUMULATION IN THE CYPRESS SANDSTONE IN THE HERALD POOL, WHITE AND GALLATIN COUNTIES, ILLINOIS*

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Introduction

The Herald pool is located in White and Gallatin counties in southern Illinois (fig. 1). The pool covers an area of approximately 1600 acres. Since its discovery in 1940, a total of 130 producing wells have been completed, of which 65[1] have produced oil from the Cypress sandstone. This sandstone has been chosen for study, and the discussion following is confined to it.

The Cypress is one of the lower formations of the Chester series. In the Herald pool area it consists of three sandstones, commonly with interbedded shales. The two lower sandstones are thick and fairly consistent, and sometimes separated by thin shale. It is the upper sandy zone which is productive in the Herald pool. It is an extremely variable zone of shale, sandy shale, and sandstone. The sandstone ranges from a tightly cemented sandstone to a clean permeable quartz sandstone, which is the pay zone. Normally the sandstone is overlain by shale or shaly sandstone. Occasionally the whole upper zone becomes a shale or shaly sandstone. In places there is no shale above the sandstone, so that it is directly overlain by the Barlow limestone. However, in most cases, it is the shaly layer over the pay zone which forms the caprock.

Structure

The Herald pool is in the southern part of the Illinois basin. The structure of the pool consists of three "highs," with a general north-south trend. Figure 1 shows structure contours on the base of the Barlow limestone, that is the top of the Cypress formation. In general the Cypress production is controlled by these features. The northernmost anticline is the largest of the three and has on it the largest number of wells.

Figure 2, (sec. 3, T. 7 S., R. 9 E.) shows oil accumulation in a simple structural trap. The wells high on the structure produce oil and water; those low on the structure are dry holes, often producing water with possible shows of oil. The closure of the pay is about 6 feet.

The strata in the southern part of the pool are cut by a fault or fault zone, which strikes north and northeast and dips eastward about 50° to 65°. The fault there cuts a structural high on the Cypress. On the upthrown side—the west side—the pay dips westward from the fault (fig. 3, secs. 22, 23, T. 7 S., R. 9 E.). Several wells produce oil near the fault. It is probable that the trap is sealed by an impervious bed on the opposite face of the fault which is in contact with the pay.

Depositional Variations

Although the Cypress production in the pool is generally controlled

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[1] Secs. 27, 33, 34, 35,—6S-9E; Secs. 2, 3, 4, 10, 11, 14, 15, 22, 23,—7S-9E.
Includes three wells producing from other formations also.

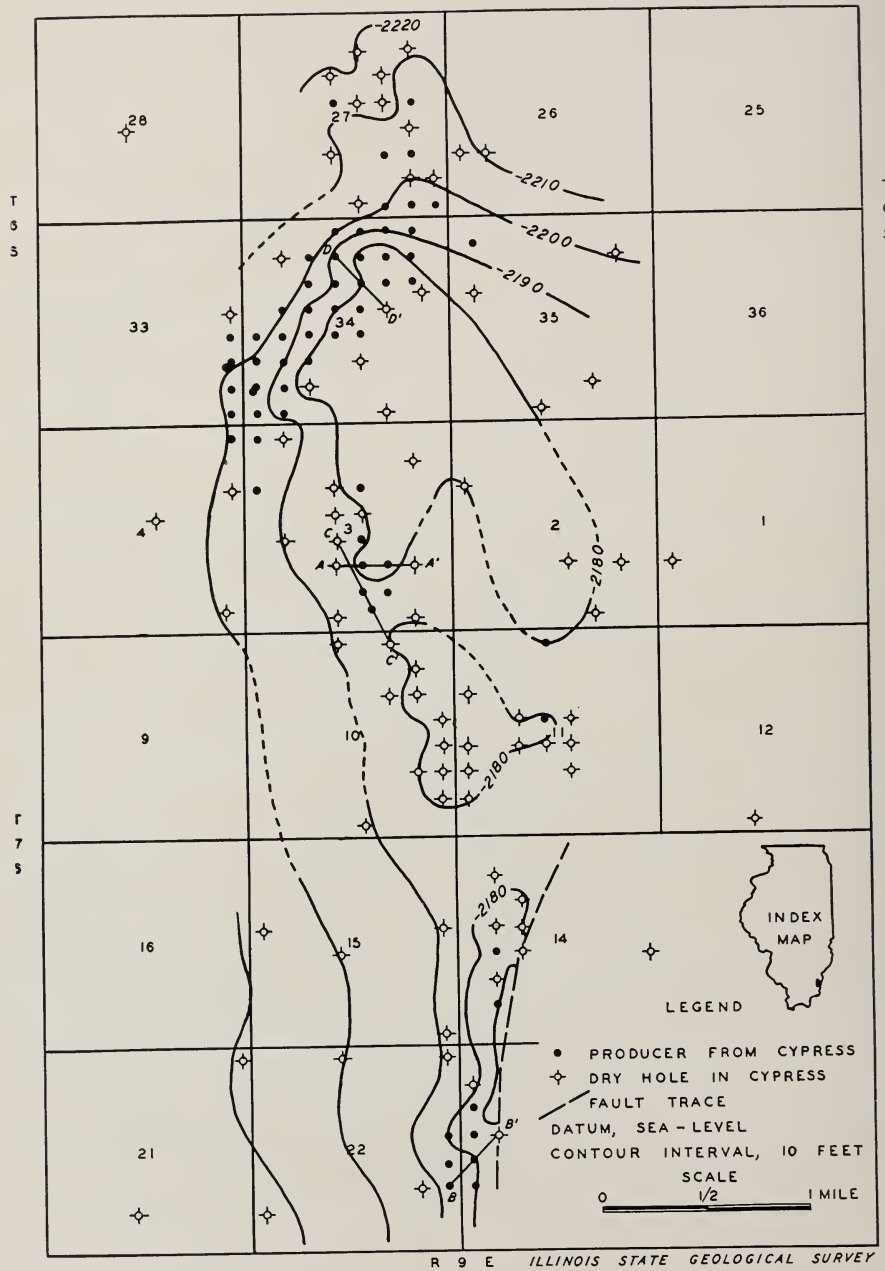

FIG. 1.—Structure map of the Herald pool. Locations of cross-sections are shown by straight lines. Index map of Illinois shows location of the pool.

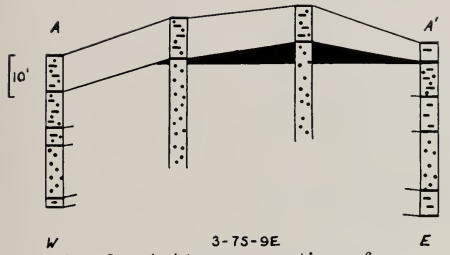

FIG. 2.—A-A′, cross-section of a structural trap.

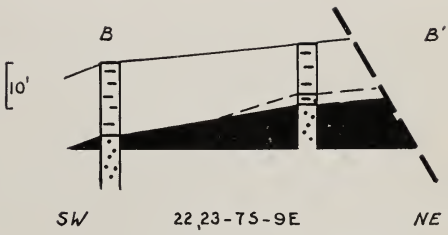

FIG. 3.—B-B′, cross-section of pay zone cut by fault.

by structure, conspicuous deviations of the production pattern from the structure pattern indicate the presence of another significant factor—depositional variations.

The shaly zone above the pay is of variable thickness. Changes in its thickness accentuate or nullify the effect of structure in forming traps. If the shale interval is fairly constant, the pay is high where the structure is high—as in the structural trap shown in figure 2. If the shale thins where structure is low, the pay there may be high. In sec. 3, T. 7 S., R. 9 E. (figure 4) such variation of shale thickness is sufficient to form a trap where the structure is low. Producers are structurally low, dry holes that produce water are structurally high.

Another important depositional variation is a change in the permeability of the pay. The sandstone may become shaly or interbedded with numerous thin shale streaks; commonly the interstitial spaces of the sandstone are filled with siliceous cement; in sandstone that is poorly sorted, the smaller grains fill the spaces between the larger ones; the sandstone may be lenticular. Such permeability changes are typical of Illinois "oil sands," where lateral variation of beds occurs commonly within a few acres, often within a few feet.

The distribution of producing wells on the anticline in sec. 34, T. 6 S., R. 9 E. is a striking illustration of the effect of permeability change, figure 5. There are many producers on the northwest flank of the anticline and several on the crest. On the highest part of the structure, however, are several dry holes. Sample studies show the pay in these wells to be shaly or cemented. The tight zone, cutting across the anticline, forms an effective seal for the oil accumulated along the flank of the structure.

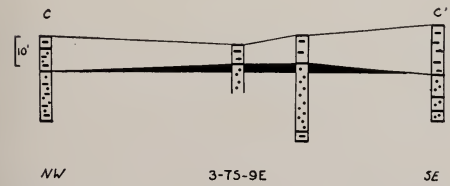

FIG. 4.—C-C′, cross-section showing effect of varying thickness of overlying shale on the trap.

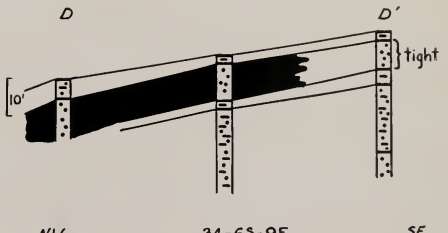

FIG. 5.—D-D′, cross-section of pay zone sealed by tight zone.

The small anticline in secs. 10 and 11, T. 7 S., R. 9 E. is a structure almost completely dry because of tightness of the sandstone. Only one well produces on this structure. The pay zone in the other holes on the anticline, though high, is shaly. The tested permeability of the sandstone in one of the highest wells averages only twelve millidarcies. Permeability of the pay in some producers in the pool averages eighty millidarcies.

These are primary features, related to conditions of deposition. In contrast, the structural features are the result of deformation.

Depositional variations on producing structures account for a number of dry holes throughout the pool.

Summary

Production from the Cypress sandstone in the Herald pool shows the effect of both structural and stratigraphic features on oil accumulation. There are examples in the pool of oil in the Cypress sandstone in the following types of traps:

Simple structural trap.
Trap sealed by an impervious bed at the fault contact.
Trap closed by thickening of overlying shale.
Trap sealed by a tight zone in the pay across an anticline.

There are also examples of areas high on structure which are dry because of depositional variations:

Thickening of overlying shale.
Tightness of producing sandstone.

Location Sec.-T.-R.	Spot	Company	Farm and Well	Depth to Base of Barlow	Surface Elevation	Subsurface Elevation: Base of Barlow	Producer or Dry Hole
26-6S-9E	SW NW SW	Angle-Gilpin	Marlin 1	....	412	.....	Dry
	SE NW SW	Angle-Gilpin	Marlin 2	....	389	.....	Dry
	NE SE SE	Gilpin	Marlin 1	2617	403	–2214	Dry
27-6S-9E	SE NW SE	Shaffer-Stoll	A. B. And 1	2645	440	–2205	Producer
	NE NW SE	Shaffer-Stoll	A. B. And 2	....	...	.....	Dry
	SW SE NE	Carter	A. G. And 1	2635	431	–2204	Producer
	SW NW NE	N. V. Duncan	A. G. And 1	2643	424	–2219	Dry
	SW NE SE	Shaffer-Stoll	A. G. And 1	2641	439	–2202	Producer
	NW NE SE	Stoll	A. G. And 4	2641	432	–2209	Dry
	SE SE NW	Skelly	E. T. And 1	2704	488	–2216	Producer
	NE SE NW	Skelly	E. T. And 2	2664	453	–2211	Dry
	SE NE SW	Pure	J. And A-1	2670	457	–2213	Dry
	SE SW SE	Pure	J. And A-2	2650	447	–2203	Producer
	SW SW SE	Pure	J. And A-3	2661	453	–2208	Dry
	NE NE SW	Bates & Lichlyter	M. D. And 1	2705	495	–2210	.....
	SE SW NE	Skelly	M. D. And 1	2660	446	–2214	Dry
	SW SW NE	Skelly	M. D. And 2	2686	469	–2217	Dry
	NE SW NE	Skelly	M. D. And 3	2639	427	–2212	Dry
	SW NE NE	Carter	Austin 3	2625	411	–2214	Dry
	NW NW NW	Pure	Austin-Wilson 1	2688	443	–2245	Dry
	NE SE SE	Angle-Gilpin	Marlin 1	....	432	.....	Dry
	SW SE SE	Gilpin	Marlin 1	2605	410	–2195	Producer
	NW SE SE	Gilpin	Marlin 2	2624	424	–2200	Dry
	SE SE SE	Gilpin	Marlin 4	2614	415	–2199	Producer
28-6S-9E	NE NE SW	Amsco	Austin 1	2721	451	–2270	Dry
33-6S-9E	SE SE NE	Carter	And 1	2717	510	–2207	Dry
	NE SE SE	Pure	Holland 1	2736	538	–2198	Producer
	SE SE SE	Pure	Holland 2	2720	521	–2199	Producer
	SE NE SE	Yoder	Holland 4	2719	517	–2202	Producer
	SE NE SE	Yoder	Holland 4-A	2718	517	–2201	Producer
	NE NE SE	Yoder	Holland 5	2720	515	–2205	Producer
34-6S-9E	SE NW NW	Pure	Austin Consol. B-1	2704	496	–2208	Dry
	NW SE SW	Pure	Holland A-1	2694	516	–2178	Dry
	NE SW SW	Yoder	Holland 1	2695	508	–2187	Producer
	NW SW SW	Yoder	Holland 2	....	499	.....	Producer
	NW SW SW	Yoder	Holland 2-A	....	501	.....	Producer
	SW SW SW	Yoder	Holland 3	....	504	.....	Producer
	SE SW SW	Yoder	Holland 6	2687	501	–2186	Producer
	SE NW SW	Carter	McCallister 1	2722	532	–2190	Producer

Table 1.—Data for Wells on Structure Map—Continued

Location Sec.-T.-R.	Spot	Company	Farm and Well	Depth to Base of Barlow	Surface Elevation	Subsurface Elevation: Base of Barlow	Producer or Dry Hole
	SW NE SW	Carter	McCallister 2	2709	530	–2179	Producer
	SW NW SW	Carter	McCallister 3	2723	525	–2198	Producer
	NE NW SW	Carter	McCallister 4	2728	531	–2197	Producer
	NW NE SW	Carter	McCallister 5	2657	472	–2185	Producer
	NE NE SW	Carter	McCallister 6	2638	461	–2177	Producer
	NW NW SW	Carter	McCallister 7	2729	526	–2203	Producer
	SE SW NW	Yoder	McAllister 2	2727	524	–2203	Producer
	SW SE NW	Yoder	McAllister 3	2663	474	–2189	Producer
	SE SE NW	Yoder	McAllister 4	2618	436	–2182	Producer
	NE SE NW	Yoder	McAllister 5	2657	467	–2190	Producer
	NW SE NW	Yoder	McAllister 6	2702	504	–2198	Producer
	SW NW NE	Carter	Merritt 1	2632	453	–2179	Producer
	NW NW NE	Carter	Merritt 2	2643	452	–2191	Producer
	SE NW NE	Carter	Merritt 3	2606	429	–2177	Producer
	NE NW NE	Carter	Merritt 4	2619	429	–2190	Producer
	SW NE NE	Carter	Merritt-Webb C-80-1	2606	423	–2183	Producer
	NW NE NE	Carter	Merritt-Webb C-80-2	2628	429	–2199	Producer
	SE SW SE	Gilpin	Newcomb 1	2654	479	–2175	Dry
	SE NE NW	Texas	Pool 1	2635	448	–2187	Producer
	NE NE NW	Texas	Pool 2	2684	482	–2202	Producer
	SW NE NW	Texas	Pool 3	2647	445	–2202	Producer
	NW NW SE	Pure	B. Weasel 1	2638	463	–2175	Producer
	SW NW SE	Pure	B. Weasel 2	2649	478	–2171	Dry
	C SE NE	Carter	C. Weasel 1	2581	409	–2172	Dry
	SW SW NE	Carter	C. Weasel 2	2614	440	–2174	Producer
	NW SW NE	Carter	C. Weasel 3	2598	417	–2181	Producer
	NE SW NE	Carter	C. Weasel 4	2584	410	–2174	Producer
	NW SE NE	Carter	C. Weasel 5	2578	405	–2173	Producer
	SE SW NE	Carter	C. Weasel 6	2633	458	–2175	Dry
35-6S-9E	SE SE SW	Carter	And 1	2625	441	–2184	Dry
	C SW NW	Carter	Marlin 1	2638	456	–2182	Dry
	NE SW SE	McBride	Porter 1	2604	419	–2185	Dry
	SW NE NE	Slagter	Questell 1	2634	433	–2201	Dry
	C NW NW	Carter	Webb C-81-1	2593	397	–2196	Producer
1-7S-9E	SW NW SW	Kingwood	Pyle 1	2917	497	–2420	Dry
2-7S-9E	NW SW NW	Kingwood	Bayley 1	2690	510	–2180	Dry
	SE SW SW	McCummings	Bayley 1	2668	481	–2187	Dry
	330SL, 410WL, NE SE	McGraw-Sullivan			491	–2173	Dry

Location Sec.-T.-R.	Spot	Company	Farm and Well	Depth to Base of Barlow	Surface Elevation	Subsurface Elevation: Base of Barlow	Producer or Dry Hole
3-7S-9E	SW NE NE	Gilpin	And 1	2667	490	–2177	Dry
	SW NE SE	McBride	And 1	2655	472	–2183	Dry
	NW NW NW	Carter	Bayley 1	2673	480	–2193	Producer
	NE NW NW	Carter	Bayley 2	2669	474	–2195	Dry
	NW SW NE	Gilpin et al	Bayley 1	2670	494	–2176	Producer
	SW SW NE	Gilpin	Bayley 2	2669	488	–2181	Dry
	NW NW SE	Gilpin	Bayley 3	2680	497	–2183	Producer
	SW NW SE	Gilpin	Bayley 4	2670	493	–2177	Producer
	SE NW SE	Gilpin	Bayley 5	2669	495	–2174	Producer
	580SL, 580WL, SE	McBride	Bayley 1	2675	491	–2184	Producer
	SW SE SE	McBride	Bayley 2	2666	477	–2189	Dry
	NW SW SE	McBride	Bayley 3	2697	510	–2187	Producer
	NE SW SE	McBride	Bayley 4	2673	490	–2183	Producer
3-7S-9E	NW SW NW	Q. B. Mitchell	Fulkerson et al-1	2722	530	–2192	Producer
	SE SE SW	Tidewater	Millikan 1	2659	470	–2189	Dry
	NE SE NW	Fox & Fox	O'Neal 1	....	496	.....	Dry
	SE SE NW	Fox & Fox	O'Neal 2	2677	491	–2186	Dry
	NE NE SW	Kingwood	O'Neal 1	2677	493	–2184	Dry
	SE NE SW	Kingwood	O'Neal 2	2682	497	–2185	Dry
	NE NW SW	Mitchell	O'Neal 1-B	2708	519	–2189	Dry
4-7S-9E	NE NE NE	Pure	Holland B-1	2726	528	–2198	Producer
	NE SE NE	Pure	Holland B-2	2709	514	–2195	Dry
	560SL, 560EL,	McBride	Millikan 1	2640	441	–2199	Dry
	SW SW NE	Carlson	Orr-Fulkerson	....	515	.....	Dry
10-7S-9E	NW SE NE	Kingwood	Bayley 1	2614	438	–2176	Dry
	SE SE NE	Kingwood	Bayley 2	2612	436	–2176	Dry
	NE NE NW	Shulman Bros.	Bayley 1	2643	454	–2189	Dry
	NE NW NE	Mabee	Harris 1-A	2652	472	–2180	Dry
	SW NE NE	Carter	Hendrix 1	2624	444	–2180	Dry
	NE NE SE	Kingwood	Knight 1	2614	439	–2175	Dry
	SE NE SE	Kingwood	Knight 2	2617	444	–2173	Dry
	NE SE SE	Kingwood	Knight 3	2612	434	–2178	Dry
	SW NE SE	Kingwood	Knight 4	2613	432	–2181	Dry
	SW SW SE	Mabee	Knight 1	2608	417	–2191	Dry
	NE SW NE	Carter	Weas 1	2623	436	–2187	Dry
11-7S-9E	NW NW SW	Gulf	Bayley 1	2607	430	–2177	Dry
	SW NW SW	Gulf	Bayley 2	2603	427	–2176	Dry
	NW NE SW	Gulf	Bayley 3	2617	438	–2179	Dry
	NW SW SW	Gulf	Bayley 4	2598	419	–2179	Dry

Table 1.—Data for Wells on Structure Map—Concluded

Location Sec.-T.-R.	Spot	Company	Farm and Well	Depth to Base of Barlow	Surface Elevation	Subsurface Elevation: Base of Barlow	Producer or Dry Hole
	NE NE SW	Gulf	Bayley 5	2613	432	–2181	Dry
	NW SW NW	Kingwood	Bayley 3	2637	462	–2175	Dry
	NW NW SE	Leach	Bayley 1	2607	424	–2183	Dry
	SW NW SE	Leach	Bayley 2	2619	431	–2188	Dry
	SW SW NE	Carter	Dagley 2	2623	437	–2186	Dry
	NE NE NW	Bennett Bros.	Questell 1	....	479	.....	Dry
	SW SE NW	Lewis	Questell 1	2622	442	–2180	Dry
	SE SE NW	McCummings	Questell 2	2617	438	–2179	Producer
	300NL, 330EL, NE NW	McCummings	Questell 6	2662	482	–2180	Producer
12-7S-9E	SE SE SW	Wilson	Dagley 1	2745	417	–2328	Dry
14-7S-9E	NE SW SW	Oil Management	Bayley 1	2577	407	–2170	Producer
	SE SW NW	Oil Management	Harrell 1	2606	433	–2173	Dry
	SW SE NW	Oil Management	Harrell 3	2603	423	–2180	Dry
	NW SE NW	Oil Management	Harrell 4	2617	439	–2178	Dry
	SE NW NW	Carter	Knight 1	2618	432	–2186	Dry
	NW NE SW	Oil Management	Williams 1	2634	394	–2240	Dry
	SE NW SW	Oil Management	Williams 2	2578	405	–2173	Dry
	NE NW SW	Oil Management	Williams 3	2582	404	–2178	Producer
	NE NE SE	Spires	Williams 1	2719	396	–2323	Dry
15-7S-9E	SE SE SE	Phillips	Bourland 1	2633	445	–2188	Dry
	SE SE NE	Phillips	Bourland 2	2591	402	–2189	Dry
	SW SW NW	Anderson	Knight 1	2603	400	–2203	Dry
	NE NE SW	Self	Knight 1	....	412	.....	Dry
21-7S-9E	NE NE NE	Skelly	Hale 1	2611	404	–2207	Dry
	NE SE SW	Ryan	Mills 1	2596	387	–2209	Dry
22-7S-9E	SW NE SE	Aetna & Oil Management	T. H. Boyd 2	2607	411	–2196	Dry
	NE NE SE	Aetna & Oil Management	T. H. Boyd 4	....	402	.....	Producer
	SE NE SE	Aetna & Oil Management	T. H. Boyd 5	2586	401	–2185	Producer
	NW SW SW	Carter	Hale 1	2632	413	–2219	Dry
	NE NE NE	Fryer	Jones 1	....	428	.....	Dry
	SE SE NE	Oil Management	Jones 2	2593	414	–2179	Producer
	NE NE NW	N. V. Duncan	Knight 1	2613	412	–2201	Dry
23-7S-9E	SW NW NW	Fryer	C. H. Boyd 2	2588	399	–2189	Dry
	NW SW NW	Red Bank	C. H. Boyd 1	2567	394	–2173	Producer
	SW SW NW	Red Bank	C. H. Boyd 2	2568	390	–2178	Producer
	SE SW NW	Red Bank	C. H. Boyd 3	2709	389	–2320	Dry
	SW NW SW	Claude Neon Lights	T. H. Boyd 2	....	390	.....	Producer

PSYCHOLOGY AND EDUCATION

EDUCATIONAL PLANS OF ILLINOIS HIGH SCHOOL STUDENTS IN RELATION TO FINANCIAL SITUATION AND ACADEMIC APTITUDE

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This report is concerned with the plans of Illinois high school juniors and seniors to continue their formal education beyond the high school level; with their ability, both scholastic and financial, to make these plans effective; and with the implications which arise out of the findings, both for our public educational system and for society at large.

The data for this study were collected by the High School Testing Bureau at the University of Illinois, which each year directs the Illinois statewide testing program. The data include: first, the information supplied by the juniors and seniors themselves concerning their plans for continuing formal education beyond the high school level; second, the report which the high school principal makes on each student concerning his scholastic promise and his financial ability to continue education after high school graduation; and, third, the scores which each student makes on the American Council on Education psychological examination. This test is primarily a measure of scholastic aptitude and is often used for guidance purposes in appraising the student's likelihood of success at the college level. It might be noted here that students' plans to continue formal education beyond the secondary school include plans for attending business college, vocational and trade schools, the junior college, or other types of educational institutions as well as the standard four-year college and university.

Almost two thirds of the public and private high schools in Illinois, exclusive of the public schools in Chicago, participate in the Illinois statewide testing program. Most high schools test at the junior level, so that data on well over 30,000 junior students are available each year. The Bureau also receives data each year on approximately 8,000 senior students. It is these juniors and seniors, or representative groups of them, on which the figures in the present report are based.

Students' Plans

Of the high school juniors who participated in the statewide testing program during the current year, approximately 2,000 were selected on a stratified sampling basis as representative of the total group. The responses of these students show that approximately 66 percent have plans for continuing education beyond the high school level. Thirty-three percent do not plan to seek further education, while about 1 percent are undecided. A breakdown by sex shows no statistically significant difference in these figures and would indicate that sex is not an important factor in determining whether a student will plan to con-

tinue with his formal schooling. The direction of difference, however, favors a slightly greater proportion of junior girls than of junior boys who plan to continue.

Data from three previous years, two of them since the war and one while the war was at its height, show only slightly lower percentages of junior students who plan to continue education beyond the high school than are shown in the figures of the current year. These figures range from 58 to 62 percent for the boys and from 62 to 65 percent for the girls. In other words, there is little variation in the percentage of juniors each year who plan to continue their formal education, although that variation which does exist points in the direction of an increase which currently includes almost two-thirds of all junior students in Illinois high schools.

The educational plans of high school seniors have not yet been studied for the present year, but data from previous years indicate that what is true for the juniors is generally true for the seniors as well. A slightly greater proportion of senior boys than of junior boys plan to continue with their education, for at this level the figures range from 60 to 65 percent. On the other hand, a slightly smaller proportion of senior girls than of junior girls have further educational plans, so that in the senior group the proportion of boys who plan to continue education after high school graduation is slightly greater than the proportion of girls, though the difference is still not statistically significant. It is safe to generalize that among both boys and girls, at both the junior and senior levels, approximately two thirds of all Illinois high school students plan to carry on school work beyond the secondary level.

Scholastic Aptitude

How do these students with plans for further education stand scholastically? Are those who are most able to benefit by continuing education beyond high school the ones who plan to do so? These questions are important ones to ask if we are concerned with an educational system that meets the needs and abilities of every student and one that serves the best interests of society by preparing for responsible professional and leadership positions all those who have the ability to function at such levels in society.

When we consider the report made by the high school principal on each student in the statewide testing program, we find there is a definite positive correlation between the scholastic promise of students and their plans for continuing education. In the current year approximately 83 percent of all junior girls planning further education are reported as possessing scholastic promise, whereas, only 49 percent of the girls not planning further education are so reported. Among the junior boys the percentages are somewhat lower, being 70 percent of those planning to continue education and only 29 percent of those not planning to continue. The figures from former years are similar, in every case a higher percentage of girls than boys being reported as showing scholastic promise and a higher percentage of those with plans for further education than of those without plans being so reported. In every case, too, the percentage of those showing scholastic promise is higher for senior students than for juniors. The picture is always the same, however, in showing a considerably higher proportion of students with scholastic promise among those who plan to continue their education beyond the secondary school level than

among the group of students who do not have such plans.

Another way of determining the student's aptitude for scholastic achievement beyond the high school level is the score he makes on the American Council psychological examination, which is used in the statewide testing program. Current figures show that of those junior students who plan to continue education approximately 68 percent are in the upper half of scores on the A.C.E. psychological test. Only 37 percent of those who do not plan to continue stand in the upper half on the test. Putting it another way, of those students who stand in the upper half on test scores approximately 78 percent plan to continue education as compared with only 49 percent of those who stand in the lower half on test scores. These figures vary somewhat from group to group but remain substantially the same for both boys and girls and for both junior and senior students. Likewise, they are fairly constant over a period of several years, although a slight trend might be noted in the direction of an increased number planning to continue education both among the group in the upper half on test scores and among the group in the lower half.

The significant fact in the figures presented thus far is not that those students who plan to continue education beyond the high school level are predominantly the ones who possess scholastic promise or stand high on test scores. That is not an unexpected discovery. But it is important to note that from 30 to 50 percent of those students who *do not plan* to continue further education possess the ability and promise of doing successful work at the college level. What is the reason that such a large proportion of students have no plans for pursuing further education even though they have the ability to do so, and even though our educational system purports to meet individual and societal needs by offering the maximum opportunity for development to all individuals?

Financial Ability of Students

Perhaps one answer to the question just asked lies in the financial ability of students to continue schooling beyond the high school level. Our principals' reports show that over 45 percent of all students are not able financially to continue with their education after high school graduation. Undoubtedly a large number of these also lack the scholastic ability or promise that would make it desirable for them to go on with advanced education. But the reports indicate that of those students who are rated as possessing scholastic promise, an average of over 35 percent, or one in three, does not have the financial ability to continue his education beyond high school. Of those students who stand in the upper half on the A.C.E. psychological test, approximately one third are reported from families whose financial situation does not encourage them to make plans for further education.

We can look at the figures in another way by comparing the group who have educational plans with the group who do not have such plans. In the latter group there is approximately twice as great a percentage reported as having scholastic promise but lacking in financial ability as there is in the group planning to continue education. Among the students who rank in the upper half on the A.C.E. test, over 60 percent of those who do not plan to continue are financially unable to do so, whereas less than 30 percent of those who do plan to continue education are reported in unfavorable financial circumstances. These

figures would seem to indicate that lack of financial ability is one of the major reasons why many high school students do not plan to continue their education beyond the secondary level, even though they possess the scholastic promise and aptitude for doing successful work at a higher level.

Democratic Implications

The figures presented thus far tell a story that carries meaning for our schools and for the community and nation at large. At the local school level the question of individual pupil guidance concerning educational matters involves: how especially to assist and encourage the student to continue with his education when he has the scholastic promise and ability but has made no plans to carry on beyond the high school level; how, too, to help the individual student overcome problems which stand in the way of continuing his education because of financial circumstances that are unfavorable to his continuance. These are problems that are local and specific in nature, but above and beyond them are more important problems which concern our entire educational program and the part that our educational system plays in the society in which we live.

The fundamental purpose of the schools in a democratic society is promotion of the maximum development of every individual to the end that both individual and group welfare are served in the greatest possible extent. If democracy is to triumph over communism and other forms of totalitarian society, it must do more than pay lip service to its ideals. As a nation we cannot afford to squander human resources by failing in our schools to achieve the optimum development of every individual in order that he may contribute his best to our democratic way of life. Yet when we find that over one third of our young people who possess capacities for growth and development beyond the high school level are unable to make plans for continuing their education because of financial reasons, we realize that our educational system has a long way to go to meet individual needs and a long way to go to fulfill its function in society.

The schools alone are not to be blamed, but educators themselves have the major responsibility in thinking through the problem and promoting an adequate solution for it. Our educational system may have to be expanded until the junior college becomes recognized as a fundamental part of the free public school structure. It may be necessary to establish educational benefits for civilian youth, as President Stoddard of the University of Illinois has suggested, in order to provide an advanced educational program for all those who can benefit by it, regardless of their financial circumstances. Certainly the problem is one which concerns our national government as well as the states. It is a problem for all of society to ponder, for it involves the fundamental democratic issue of whether every individual can expect to achieve maximum personal growth and development or whether some, because of the circumstances into which they fall or are born, cannot expect the same opportunities and advantages as others.

The Illinois State Academy of Science is already recognizing the problem to a limited extent through its participation in the science talent search, which is sponsored each year by Westinghouse. The Academy endeavors to secure scholarships in Illinois colleges and universities for top-ranking high school science students who have entered the national

competitive program but have not been selected at that level. This effort is an example of what can be done in selecting students who show outstanding promise and giving them the opportunity and encouragement to go on. It is a limited effort, however, for it is restricted to students interested only in the various fields of science. It does not purport to recognize financial need as one of the factors in the selection of students for scholarships, although in some cases, undoubtedly, selection for a scholarship provides the opportunity without which talented students could not plan to continue their education. Perhaps a program of selection might be worked out which would give greater recognition to financial need but at the same time maintain present high standards in the recognition of science ability. Perhaps, too, the program could be adopted by other state and national groups for granting recognition and aid to promising students in fields other than science. In this way, we might at least alleviate the situation by providing greater opportunity for outstanding students regardless of their financial circumstances.

In this paper, however, I do not presume to find an answer to the problem. I only wish to call to your attention that a problem does exist, and that our democratic values and welfare as a nation will suffer until a solution is found. The problem remains one of promoting greater democracy and the social good by finding an answer which will enable all high school students who possess scholastic ability to continue with their education at an advanced level without regard to their financial ability to carry them through such a program.

SOCIAL SCIENCE

ADMINISTRATIVE PROBLEMS OF TOWNSHIP GOVERNMENT IN DU PAGE COUNTY

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Within Du Page County, Illinois, there are nine township governments each of which has an independent existence. They are all similar in organization and area and provide practically identical services. Some of these townships have become almost entirely urban areas, while others remain predominantly rural in their population and attitudes. Basically there is no discernable difference in the services provided by the two types. Both are interested primarily in the building and maintenance of roads, the distribution of poor relief, and the assessing of property for tax purposes. In addition to these basic interests there are other minor functions which vary from township to township.

TABLE I.—POPULATION CHARACTERISTICS[a]

York, Naperville and Winfield Townships, DuPage County, Illinois

Township	Total Population	Rural %	Urban %
York	29,161	7.1	92.9
Naperville	3,616	28.9	71.1
Winfield .	6,857	42.8	57.2

(a) Source: U. S. Bureau of Census; 1940 Census, Vol. I, Population, p. 299.

The primary function of the township is to act as an administrative district for the county and state governments. The county depends upon the township for an accurate assessment of property. This assessment is used as the basis for determining all tax rates within the county. In addition to providing the county with an assessment, the township is used as an election district for all county, state, and national elections.

The relations of the township are not confined to the county but extend as far as the state government and even, in some instances, as far as the national government. This latter extension of relations deals primarily with roads while the former deals with both roads and poor relief.

There are a great many functions provided by statute which the township is supposed to perform. Some of these are: repairing roads and bridges; maintenance of town cemeteries; care of the poor and indigent; preventing growth and spread of noxious weeds; promoting planting and cultivation of trees along highways; making rules and regulations concerning fences; preventing the running at large of cattle, horses, mules, asses, swine, sheep and goats; establishing and maintaining pounds; repairing and regulation of public wells, etc.[1] Today, about the only functions actually carried on by the township are the maintenance of roads, the care of the poor and indigent, and the assessment of property. The other functions, while

[1] *Illinois Revised Statutes*, 1945.

still in the statutes, are either obsolete or simply ignored.

The affairs of the township are administered by elected township officers, each of whom attends to the duties assigned him by law and cooperates with the other officers when it is necessary. The supervisor of the township is the general administrative head and also treasurer. He is, in addition, a member of the county board and ex-officio overseer of the poor. The other elective officers of the township are the township clerk, assessor, highway commissioner, and justices of the peace. A board of auditors composed of certain of these town officers is established to examine the township accounts. Most of the elected officers are paid on a per diem basis. The per diem rate is set by state statute. The supervisor is eligible to receive two separate payments; a per diem as supervisor and a salary as overseer of the poor.

The necessary funds for the operation of the township are appropriated by the voters at the annual town meeting. The township budget is the financial plan for operating the township during the fiscal year. The official budget is drawn up by a budget committee, usually the board of town auditors, sometime prior to the time set by law for the town meeting. At least one public hearing is held on this budget prior to final action by the people at the town meeting. Notice of the hearing is given one week prior to the time set. This public hearing is often called for one hour prior to the town meeting. Because of this practice there is little real opportunity for an interested citizen to bring any effective protest concerning the budget. At the meeting copies of the budget are not available for examination and when it is read by the town clerk, as required by law, it is frequently read so rapidly that it is impossible to obtain adequate notes. After the budget is read, there is opportunity for the town's people to ask questions, or to propose amendments to the budget. Questions are seldom asked or amendments proposed, for the people present usually do not know enough about the budget to ask questions. If any citizen or group of citizens did wish to make a change, it would be illegal for them to propose an alternate budget. The only recourse that the citizens have is to amend the official budget. This method allows the revision of specific items, but a general revision by this procedure is practically impossible.

After opportunity for discussion and amendment the proposed budget is put to a vote. It takes only a simple majority of the voters present to pass the budget. This vote must either accept or reject the budget as a whole. If the voters present fail to approve a budget there can be no legal expenditure of any funds by the township officers. If the budget is accepted, there must also be voted a levy authorizing the procurement of the funds necessary to execute the budget, unless there is a sufficient balance left on hand from the previous year.

The argument most frequently advanced in support of township government is that it gives the people a chance to exercise direct democracy—that the people have an opportunity to come together once a year and either approve or disapprove of their elected officers' actions. This is certainly in accord with the very best democratic traditions of our country and in the past the town meeting was one of the political highlights of the year. However, today in actual practice, the people either are not interested in their democratic privileges or they do not feel close to their township government. An average of

TABLE II.—ATTENDANCE AT TOWN MEETINGS [a]

Du Page County, April 1947

Township	Number of Registered Voters	Attendance	Per Cent Attending Meeting
Addison	6,796	17	0.25
Bloomingdale	[b]1,704	(c)	(c)
Downers Grove	16,742	23	0.14
Lisle	4,841	28	0.58
Milton	12,176	50	0.41
Naperville	2,222	16	0.72
Wayne	775	12	1.55
Winfield	4,522	15	0.33
York	19,830	194	0.98
Totals	[b]67,904	355	0.51

(a) Source: Natale, Joseph, *Local Government in Du Page County, Illinois*, p. 184.
(b) Bloomingdale not included in total.
(c) Data not available.

less than one-half of one percent of the registered voters in Du Page County attended the meetings in 1947. From the incomplete figures available for 1948 it appears that this percentage will be even lower.

The budget adopted by the town meeting generally provides for two separate funds: the town fund and the poor relief fund. The town fund includes such items as compensation for elected officials, election expenses, and all other general administrative expenses of the township. The poor relief fund includes the funds necessary for the relief of the poor and for its administration, except the compensation for the overseer of the poor which is included in the town fund.

Funds for the maintenance of roads are obtained through a separate budget which is adopted in an entirely different manner. This budget is drawn up by the highway commissioner and then presented to the town clerk who calls a special road and bridge hearing. This hearing is set for some time other than that of the town meeting. A favorite time is 10:15 on a weekday morning, thus making it inconvenient for persons to attend. Even if interested citizens should attend the hearing there is no way of forcing the commissioner to amend his proposed budget.

Since the road and bridge fund accounts for such a large proportion of the total town expenditure, 44.2 percent, it would seem reasonable

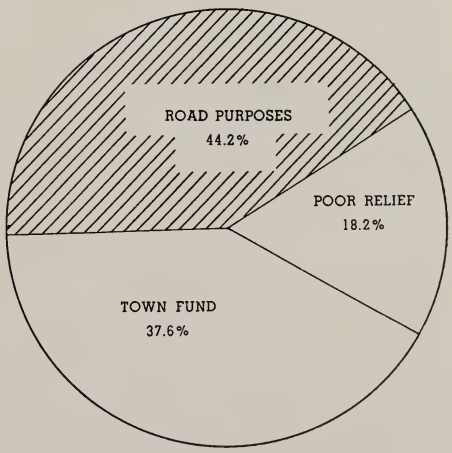

FIG. 1.—Use of funds. Source: J. P. Natale, Local Government in Du Page County, Illinois, p. 43.

that it be drafted by a more representative group. In addition it would seem only natural that it should be acted upon at the town meeting when there are apt to be at least a few voters present.

The full authority to contract bills and authorize specific expenditures lies with the township supervisor. The only exception to this is in the case of the road and bridge fund where the highway commissioner has this contractual authority. Thus the supervisor is the possessor of a large amount of financial authority. The electors of the township approve a budget at the annual town meeting, but once the appropriation is made, the actual expenditure of the money is left in the hands of one man.

Theoretically there are checks upon the supervisor's fiscal activity. One check is found in the board of town auditors, which has authority to examine and audit all charges against the township and to examine the accounts of the overseer of the poor. It will be noticed, however, that while authority is given to audit the charges against the town, there is no authority for this board to audit the township or poor relief accounts; they may merely examine them. Consider the composition of this board. It consists of the supervisor, whose accounts are being reviewed, the township clerk and the justices of the peace. All of these are elected officials. There is not one outside impartial member on the board nor one representative of the taxpayers. It can easily be seen that the probability of a good sound review is certainly open to question. The other check is in the town clerk. The town clerk must countersign all warrants issued by the supervisor. By this counter signature the clerk is supposed to attest to the validity of the warant, but there is some question that he really has the authority to hold up an expenditure authorized by the supervisor.

We have noted earlier a rather lengthy list of duties which have been given by statute to the township. We also saw that of this lengthy list only three or four are actually performed. This discrepancy is the result of a change of emphasis on the part of township government. In the early history of the state, many of these functions were a real necessity and were actively administered. For example, the law provides that the township shall see that all fences bordering township roads are mended. This, in the days when farmers in the area kept large amounts of live stock was very important. Today, with many of the townships predominantly u r b a n, this practice has fallen into disuse.

In another instance the law provides that the township shall repay farmers for any damage to livestock caused by wild dogs. To combat this menace the office of town pound-master was created. The pound-master was charged with the duty of apprehending any and all wild dogs found on town property. Today, the danger to livestock from wild dogs is almost non-existent in Du Page County. However, in many of the townships the office of pound-master is still a thriving institution with an annual appropriation for salary and expenses. Thus here and in many other instances, there is ample opportunity for the elected official to provide himself with extra funds or to provide patronage for his faithful friends.

On the other side of the picture we have instances where these antiquated township statutes have created hardship. For example, take the matter of highways. In 1920 York Township had some 40 miles of roads to maintain. The tax rates were set to produce ample funds for

this operation. Today, this same township has 80 miles of roads to maintain. Thus the number of miles of road has been doubled. In addition to the doubled mileage, the type of road which must be provided for modern transportation is much more expensive. Yet, with all this increase in operating costs, there has been no corresponding increase in the tax revenue to provide the necessary additional funds. The authority for this increase in revenue would have to come from the state legislature.

In contrast, Naperville Township has increased its roads from 40 miles in 1920 to only 44 miles today, so that its problem is not nearly so vexing.

When we come to examine specific budgets and specific expenditures we find many things that make our task difficult. In the first place, there is no uniform system of bookkeeping or accounting among the townships. This makes the matter of interpretation difficult unless the supervisor is willing to explain his particular system. Then when comparisons are attempted there is further difficulty in placing expenditures under comparable headings, since expenditures for identical items may be listed under widely different titles.

The first thing noted in an examination of township finances is the varying tax rates. Furthermore, the township levies have steadily increased in many instances. In Naperville Township for example, the levies per thousand dollars valuation increased from sixty three cents in 1942-43 to one dollar in 1946-47. In Addison Township the levies increased from thirty-eight cents in 1942-43 to ninety cents per thousand in 1946-47. There seems to be no good reason for this difference in rates since the services performed are similar in all the townships and are similar from year to year.

Let us examine now, the expenditures of two typical townships. Two townships were chosen which, from a general overall view, appeared to be representative of the urban and rural townships of the county. Naperville Township was chosen to represent the rural. Its population is in large part rural, there being only half of one incorporated village within the township limits. It also has the reputation of possessing a good, clean township government whose officials are businessmen of high reputation in the community. In contrast, the urban township of York was chosen. York township government is known to be in the hands of professional politicians who obtain their livelihood from their political jobs.

In 1947-48 Naperville Township spent $4,792.61 on its town fund while York Township spent $33,-

TABLE III.—TOWNSHIP LEVIES [a]

Per Thousand Dollars Valuation
1942 to 1947

Township	1942-43	1943-44	1944-45	1945-46	1946-47
Addison	$0.38	$1.05	$1.07	$0.66	$0.90
Lisle	1.38	1.29	1.26	1.22	1.40
Naperville	0.63	0.57	0.95	0.97	1.00
York	0.56	0.57	0.45	0.56	0.50

(a) Source: J. P. Natale, *Local Government in Du Page County, Illinois,* p. 41.

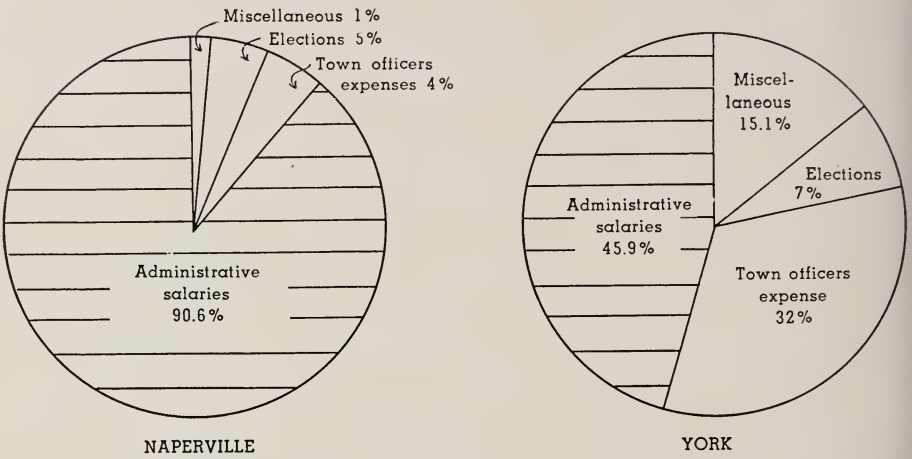

Fig. 2.—How the town fund tax dollar was spent in Naperville and York townships, 1947-1948. Source: Township records.

068.23. Thus it is readily seen that the expenses of the urban township are far greater than those of the rural. Yet the services performed by the two units are identical.

A look at the individual items of expense reveals that in Naperville 90.6 percent of the total town fund expenditure went for compensation of elected town officers. In York Township only 45.9 percent of the total town fund went for such purposes. The elected officials of the townships receive compensation for regular and special services. The amount of this compensation is set by state statute. The seemingly large expenditure for compensation in Naperville is explained by the fact that the state sets the rate at which officers must be paid. This rate of compensation thus becomes a fixed overhead cost which must be carried by all townships, irrespective of their size, and the smaller the population the larger the percentage of total expenditure this fixed overhead becomes.

But look at the other items of expenditure in the town fund. Exclu--

Table IV.—Town Fund [a]

York and Naperville Townships
1947-48

Purpose	Naperville	York
Total	$4,792.61	$33,058.23
Compensation of town officers	4,352.15	15,184.12
Elections	217.00	2,588.90
Town officers expense	193.46	10,654.26
Interest on anticipation warrants		596.49
Miscellaneous services	30.00	4,034.46

(a) Source: Township records, Naperville and York Townships.

TABLE V.—POOR RELIEF FUND [a]

Expenditures by Purpose
York and Naperville Townships
1947-48

Purpose	Naperville	York
Total	$2,476.25	$15,270.08
Home relief	1,058.96	7,944.69
Hospitalization	540.61	3,008.03
County home	876.68	1,330.12
Transient pauper relief	.....	170.42
Burial of poor	.....	110.00
Administrative costs	.....	2,706.82

(a) Source: Township records, Naperville and York Townships.

sive of the officers compensation, it costs the citizens of Naperville practically nothing to run their township government. Take for example, the "town officers' expense." This account includes such things as stationery and office supplies, printing and publishing, office help, rent, office equipment, travel and transportation. All of these things cost the citizens of Naperville slightly under two hundred dollars or 4 percent of the total expenditure for the year. In York township the bill was nearly eleven thousand dollars or 32 percent of the total expenditure for the year. Even allowing for the larger population in York, this seems to be greatly out of proportion. A brief glance at the poor relief fund (Table V) will reveal the same situation. Here, where we are able to get an exact administrative cost exclusive of compensation to the overseer of the poor, we find that it cost the citizens of Naperville exactly nothing to administer their poor fund while the people of York had to pay twenty-seven hundred dollars.

Now that we have seen some of the expenditures for our two townships let us look at the per capita costs of these two units. As we do this, keep in mind the fact that Naperville is run by businessmen who are not politicians in the usual sense of the word, but are men of high business standing who have the good of the community at heart. On the other hand, York is run by professional political machines. The first thing we note is that the total per capita cost of township government, exclusive of roads, is two dollars per person in Naperville while only one dollar and sixty-five cents in York. (See figure 3 on page 98.) Considering conditions as they are known to exist, this does not seem logical. However, when we break these total figures down we once again see that it is the compensation of town officials which forces the figures out of line. If we look at the town fund expenditures, exclusive of compensation, we find the per capita cost in Naperville to be twelve cents as against sixty-one cents for York. This gives us a much truer picture of the conditions as they actually are.

If we wish to check our figures we may use as a basis of comparison $1000 valuation of assessed property. When we do this, we find that our results are similar. They once more point to the high per capita

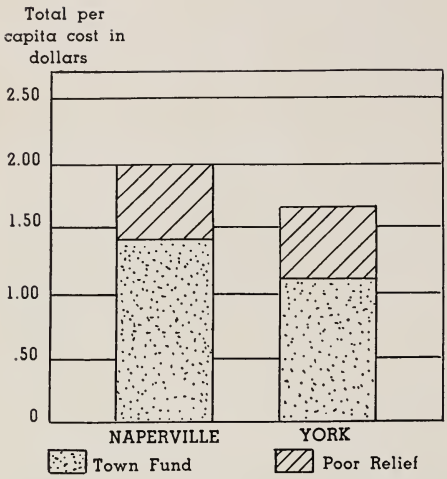

Fig. 3.—Per capita cost of government, Naperville and York townships, 1947-1948. Source: Township records.

costs of officers compensation in Naperville and the exceedingly high running expense in York.

Briefly, let us consider the administrative costs as compared to the value received for the expenditure of the poor relief fund. In York Township the total expenditures for poor relief were $15,270.08. To administer this money it cost the tax payers $5,587.52. Thus, in order to get one dollar into the hands of the poor it cost thirty six and one-half cents. Slightly more than one third of the entire poor relief fund went for purposes of administration.

In contrast look at Naperville. Here $2,476.25 was spent for relief and there were no administrative costs. Thus the tax payers received 100 percent value for their tax dollars.

This is quite a contrast. You may well wonder how Naperville reached this state of perfection. You will remember that the town supervisor also serves ex-officio as overseer of the poor. In Naperville the supervisor drew his state allowed compensation. However, he refused to draw any compensation as overseer of the poor since he felt that the remunera-

Table VI.—Per Capita and Per $1000 Valuation Costs Town Fund [a]

Naperville and York Townships
1947-48

Purpose	Per Capita		Per $1000 Valuation[b]	
	Naperville	York	Naperville	York
Total	$1.32	$1.13	$32.20	$23.40
Compensation of town officers	1.20	.52	30.00	10.00
Elections	.03	.09	$1.00	$2.00
Town officers expense	.05	.36	1.00	8.00
Interest on anticipation warrants	...	.02	...	.40
Miscellaneous services	.01	.14	.20	3.00
	.12	.61	2.20	13.40

(a) Source: Township records, Naperville and York Townships.
(b) Note: Population of Naperville 3,616
Valuation of Naperville $11,351,783
Population of York 29,161
Valuation of York $132,899,254

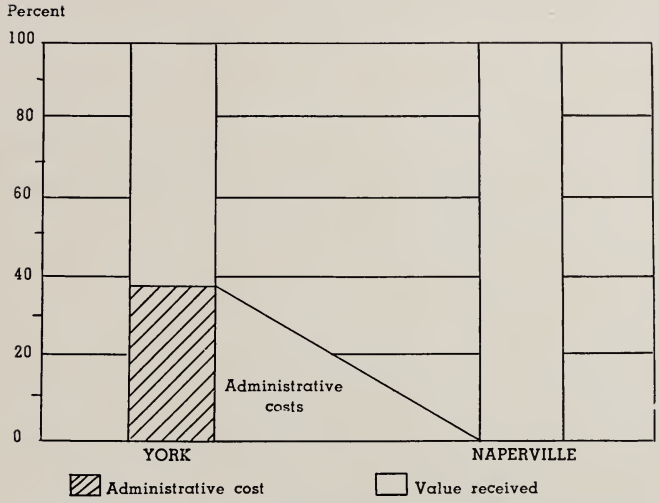

FIG. 4.—Percentage of administrative costs compared to value received, Naperville and York townships poor relief fund, 1947-1948. Source: Township records.

tion received as supervisor was more than ample pay for both offices. At the same time this man carried on his duties as overseer in his own store thus saving the township any overhead expense for office costs.

Nevertheless the fact remains that the per capita cost of township government in Naperville is exceedingly high. From these facts there is but one conclusion to be drawn. This is that the township unit of government cannot perform economically in such a small area and with such a small population. Township expenses are disproportionately high for overhead and low for services received. Compensation accounts for from one-half to nine-tenths of the townships' general expenditures. It has been shown in other studies of Illinois that, at a comparable service level, per capita costs of government were more than twice as great in counties with townships than in counties without townships,[2] and that "township organization adds to the cost of government without the addition of a commensurate service."[3] There is no government function performed by townships that other units of government could not perform more effectively.

There is almost universal agreement that abolition of the midwest townships would make for better rural government. The Committee on County Government of the National Municipal League, said:

"The objections to the retention of township government are many. There is evidence that the township places a burden on the taxpayer for which there is no commensurate return in services rendered. The major functions of government essential in the rural areas cannot be maintained economically and efficiently by township units.... In the administration of justice, health and welfare, highways, and finance, the township is no longer a satisfactory unit.... Finally, the township is an artificial area which does not conform necessarily to trade or community areas."[4]

The brief study herein presented merely adds further evidence to the support of this contention.

[2] Hicks, H. S., *County Organization vs. Township Organization*, 1932, (Mimeographed pamphlet).

[3] Hunter, M. H., *Costs of Township and County Government in Illinois*, University of Illinois Bulletin No. 45, 1933, Vol. XXX, No. 18, p. 31.

[4] Bromage, A. W., *Recommendations on Township Government* (Report No. 3 of the Committee on County Government of the National Municipal League), Supplement to National Municipal Review, Vol. XXIII, No. 2, February, 1934, p. 139.

ZOOLOGY

A SUMMARY OF STUDIES ON THE AMBUSH BUG PHYMATA PENNSYLVANICA AMERICANA MELIN (Phymatidae Hemiptera)

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Method of Study.—The data on the life cycle and natural foods were largely obtained in the field, whereas those regarding variations in the instars and the weight patterns were secured from captives. Eggs, laid by females swept from wild flowers in September-October and subsequently kept under natural conditions out-of-doors, yielded nymphs in January after exposure for 10 days to 80° Fahrenheit and about 80 percent relative humidity. Severe freezing and wetting proved necessary to produce hatching. The resulting nymphs and adults were kept individually in shell vials, each vial containing a strip of white blotting paper for support. The bugs were fed on quantitatively varied rations of adult *Drosophila melanogaster* L. and *Musca domestica* L.

Recognition and Life Cycle.—The adult is about 2/5 inch long and colored yellow, brown, and green, with a black band across the reposing wings. Being phlegmatic in temperament, it is readily weighed on the open pan of the balance. Adults may be found from July to October by searching the fresh flowers of various plants, especially mountain mint and Compositae. During this period the eggs are laid shingle-fashion in masses and covered with a golden flocculent matrix. I have not succeeded in finding the eggs in nature, but the females readily deposit them in the vials. Most adults die before November, leaving the eggs to bring the species through the winter. The nymphs hatch in May-June and complete their five instars by July. A feature of special interest is the delay in hatching. Although the embryo develops within the first 10 days after oviposition, it remains unhatched or dormant for nine months or less. Were this prolonged diapause eliminated, the species might realize two generations, instead of one, in a year.

Food and Feeding.—The adult may readily be seen sitting amid the floral parts with its anterior end elevated and alert to capture other insects that visit flowers to feed on nectar, pollen, petals and reproductive structures. As the flowers age and no longer attract its insect food, the bug flies to fresh flowers and more adequate prey. No proof was found that the predator chooses flowers whose colors tend to conceal it. The food insects present are obviously the factors that induce the bug to remain in the flower.

Both the nymphs and the adults are doubtlessly the most efficient predatory terrestrial Hemiptera in our area. They employ their extraordinary fore legs to seize their victims by the mouthparts, antennae, legs or even the wings. So powerful is *Phymata* that it can hold with one front leg a fluttering moth of superior size, and, in not a few cases, is found holding two captives simultaneously. However, the adult male

is decidedly less voracious than the somewhat larger, paler female, not only feeding less frequently but also, on the average, on smaller forms of insects.

Relatively small captives are quickly inactivated and their bodies observably enlarged as *Phymata* pumps a fluid into them through its piercing-sucking mouthparts. This fluid, presumably of a salivary sort, seems both to deaden the victim and to liquefy the non-chitinous viscera. Subsequently this dissolved matter is sucked out, leaving the discarded small prey very light in weight and the abdominal segments telescoped sharply inward.

In three years of field work, I removed 832 individual insects from the grasp of adult *Phymata*. These represented 195 species, 131 genera, 54 families and seven orders. Distributed taxonomically, the number of individuals taken were: Coleoptera, 82; Hymenoptera, 216; Lepidoptera, 134; Diptera, 346; Neuroptera, 1; Hemiptera, 52; and Homoptera, 1. All the victims were adults, excepting one small geometrid looper and three hemipterous nymphs of the families Miridae, Nabidae, and Pentatomidae.

Diet in Relation to Performance.—The relation between vital performance and quantity of food taken was studied by setting up series of 10 or 20 bugs in shell vials and providing varying numbers of *Drosophila* and *Musca*. Even the nymphs of the first instar quite readily capture the larger *Drosophila*. In some series *Musca* was supplied to the nymphs in the fourth and fifth instars and the adults. The biological effects of these differentiated diets proved to be measurable in the following terms: percentage of survival among the nymphs, length of the instars, rate of growth; weight, size, longevity, extent of sexual activity, and egg-production, among the adults. Six series of individuals were maintained on dietaries graduated from the minimum barely adequate to bring a few nymphs to adulthood, to an optimum which yielded biological results comparable with the normal performance of bugs in nature. For example, individuals that sucked out only 66 *Drosophila* required 187 days to complete the five instars, whereas nymphs that utilized the equivalent of 541 *Drosophila* grew to adulthood in an average of 50 days. Only one nymph of the low-fed series became adult,—a female, that lived but 15 days, weighed 0.0089 gram, and produced no trace of eggs. By contrast, 15 individuals of the above best-fed series became adults which lived an average of 68 days each; the pairs coupled and mated freely and the seven females among them produced slightly more than 100 eggs each and averaged 0.0602 gram in weight. The data from the intermediate series showed that a female must ingest about 120 *Drosophila* in the nymphal stage and about 225 during adult life in order to attain that state of vigor necessary to the inception of sexual activity and oogenesis. As the dietary was increased, the nymphal life became proportionately shorter, adulthood longer and the productive functions, weight and size greater.

A separate report was published that pertained to the effect of the varied diets on the duration of the instars. When the nymphs were supplied all the flies they can utilize in each and every instar, i.e. fed at a near-optimum rate, the five instars lasted the following average number of days: 7.40, 5.50, 5.60, 7.00 and 10.90 respectively, or a total of 36.40 days. These values, expressed in terms of the percent of time each instar represents in the entire

nymphal life, were: 20.35, 15.11, 15.38, 19.23 and 29.95, respectively. It will be seen that the first and fourth instars are equal in duration, as are also the second and third, while the fifth required as many days as the second and third combined. The data for 13 other series show that any instar may be attenuated to various degrees by reducing the diet. However, not all instars in the life of any one individual may be so prolonged. That is, the capacity to extend any instar decidedly beyond the usual length depends on the amount of food utilized in one or more previous instars. While the extreme of flexibility in duration was probably not demonstrated in this study, the ability to far exceed the usual duration is surprisingly great. For instance, one series of eleven low-fed individuals required an average of 138.19 days for the nymphal stage, and one female completed that stage in 185 days. It scarcely need be added that these starved bugs produced no eggs and had a brief adult life.

Economic Status.—This attempt to evaluate the economic status of *Phymata* was based on the 832 insects I had previously taken from the predator in the field. It lead to the deduction that *Phymata* is about as beneficial as destructive to our welfare. However, the principal merit of the undertaking was disclosure of the fact that determination of economic status is highly speculative and inconclusive. This is so because estimation of the economic importance of a predator, and particularly of one known to include 195 species of insect prey in its dietary, involves numerous variables and also much ignorance of the essential facts in the bionomics of the victimized species. Only a few instances need to be indicated to reveal the nature of these variables: (1) Differentials in the economic contributions made by the adults and the larvae of a prey species; in one stage, the victimized species may be beneficial as by pollination or through destruction of weeds, whereas in another stage it may be injurious; (2) a phytophagous stage may consume a variety of plants, some cultivated, some weeds; (3) the two or more generations which a prey species may have in a year can vary greatly in their importance owing to differences in the plant food, prey or hosts available to be attacked in each season; (4) the amount of harm or good performed by a species varies from year to year and from locality to locality; and finally, (5) one individual of a species may function in a friendly capacity, another in a destructive way, e. g. one bee pollenizes the flower of an apple, another a thistle. Estimates must therefore differ sharply from time to time and place to place, even granting that all the data were at hand for each situation.

Weight Pattern.—The discovery that ambush bugs obtained in the field varied greatly in weight prompted this inquiry into the amount, nature and causes of changes in weight during the lifetime of captive individuals. By weighing each daily throughout its nymphal and adult life, a body of data was secured which made possible the following characterization of the "weight pattern."

It was learned that the weight-growth curve of any one instar is essentially like that of any other when the individual is fed at the same relative rate throughout the nymphal life. This curve has the form of an attenuated capital S. The daily weights show that each instar exhibits two rather distinct phases, (1) a feeding-growing phase and (2) a molting phase. The first be-

gins when the new cuticle has set and the nymph resumes feeding, which activity had ceased with the inception of the second phase. In approximately the first three-fourths of the instar, feeding is intense, the intensity decreasing steadily however from day to day. As a consequence of such feeding, the weight rises sharply in the early days of the instar, some individuals displaying increases of 100 percent over the previous day. As the body seems to become saturated with wastes, feeding falls off and eventually ceases, with the result that the weight curve slopes off in the hours preceding the molt. Upon molting, the weight drops still more and sharply, the loss being approximately 10 percent of the pre-molt weight. Not less than 80 percent of this loss is traceable to the evaporation of fluids from the moist new cuticle, the rest to the exuviae. A state of comparative dessication is created by these losses, and it is apparent that this state stimulates the intensive feeding and sharp upswing of weight characteristic of the feeding-growing aspect of the instar.

The amount of increase in weight in any instar depends on the quantity of food ingested and on the sex of the bug, the females generally being heavier than the males. The average newly-hatched *Phymata* weighs about 0.0003 gram. At the end of the first instar, the average weight of 42 individuals had increased to 0.00094 gram, the extremes of variation being 0.0007 and 0.0014 gram. Corresponding values for the other four instars were: second, average, 0.0022, extremes, 0.0014 and 0.0040; third, 0.0065, 0.0041 and 0.0092; fourth, 0.0158, 0.0095 and 0.0231; fifth, 0.0317, 0.0193 and 0.0477 gram.

Investigators concerned with the phenomena of weight in the growing stages of insects have adopted the "growth quotient" as a convenient device to express the amount of net increase achieved in the several instars and the nymphal stage as a whole. The growth quotient is the value obtained by dividing the final weight by the initial weight irrespective of sex and diet. The quotients for the five successive instars of 28 individuals were thus: first, average 2.75, extremes 1.7 and 5.3; second, 2.62, -1.7 and 3.8; third, 2.46, -1.7 and 3.2; fourth, 2.49, -1.8 and 3.2; fifth, 2.1, -1.5 and 2.6. In the course of the entire nymphal life, the 28 individuals doubled their weights an average of 107.7 times, extremes 64.0 and 157.0. However, this great spread in extremes is reduced much when each sex is considered by itself. The males multiplied their weights an average of only 83.0 times as compared with 132.5 times for the females. The extremes for the males were 64.0 and 102.0, for the females 103.0 and 157.0. In other terms, the male nymphs gained an average of about 8000 percent, the females about 13,000 percent.

From their study of the Egyptian mantis, *Sphodromantis bioculata* Burm., Przibram and Megusar reported that the nymphs doubled their weight in each instar. This pattern of increase has come to be known as Przibram's principle of doubling. Reference to the average quotients cited above will show that *Phymata* did not conform to this principle, varying largely upward from it, the variations in the growth quotients depending on sex and the quantity of food provided. It is of interest also that the quotients secured from weights of the exuviae of well-fed *Phymata* correspond fairly well with those from the weights of the living nymphs already given.

Like the nymphs, the adults display weights that vary greatly with sex and diet. The males of all

dietary series varied from a low of 0.0185 gram to a high of 0.0391 gram, and the females from 0.0315 to 0.0628 gram. Almost without exception, the adult weighs least on its first day when it has suffered its extreme reduction due to recent molting and has not yet resumed feeding. The peak weight is attained at various time points in adulthood. If the nymph was under-fed, the adult lives only a few days and experiences its maximum weight on the day of molting or soon thereafter. Such adults are very short-lived. But the better- to optimally-fed adults achieve their maxima generally on or after the 10th day and may approach or reach the peak repeatedly afterwards. If fed at an adequate rate, the female maintains her maximum or near-maximum weight until the day of death. The principal factors causing fluctuations are ingestion and egestion, and, in the female, oögenesis and oviposition.

The weight pattern of well-fed adults embraces three fairly distinct phases, the first characterized by a slump in weight due to the losses peculiar to the final nymphal molt, the second by a sharp climb in weight that results from several days of intense feeding, and the third by its generally long horizontal plane interrupted by secondary ascents and descents arising from feeding, egestion, oögenesis and oviposition. Because the males feed less voraciously and the bulk of their sexual products is relatively minute their weight curve in the third phase is subject to a lesser degree of vertical fluctuation than that of the females.

How Much Food is Required to Grow a Bug?—The first step in the approach to this question was to determine how many *Drosophila* the nymphs sucked out in each of the five instars. Second, since it is impractical to weigh each fly just before and immediately after *Phymata* consumes its contents, I adopted an alternate method of securing the weight of substance the nymphs ingested. This method consisted simply of weighing (a) hundreds of whole living *Drosophila* and (b) hundreds of flies emptied of their contents by *Phymata,* whereupon the average weight of (b) was subtracted from the average of (a), the difference representing the bulk of food substance available in the average *Drosophila.* This value proved to be 0.0007643 gram. It was then multiplied by the number of *Drosophila* utilized, the product representing the approximate amount of food substance utilized by an individual in any instar.

In the following report of results, only the data from the third, fourth, and fifth instars are included, this for the reason that the small nymphs in the first two instars lack the capacity to ingest all the substance from a fly in one feeding. The relatively small amount required to complete these early instars was determined by estimation based on observations.

Several general theories are indicated by the data. First, the amount of food required by an individual to complete any instar or the whole nymphal stage is clearly affected by the rate at which food is supplied. To illustrate, each of eight bugs kept on a low diet ingested an average of 0.01290 gram while completing their fourth instar in 20 days, whereas each of 10 bugs kept on a more liberal diet consumed 0.04761 gram while completing the same instar in only 7.5 days. The data for the third and fifth instars and the whole nymphal life show this same kind of differences between low and more liberal diets.

Second, when the amount of raw food ingested is compared with the net increase in weight achieved in

any instar it is found that the major part of the food, or approximately three-fourths to four-fifths, is subsequently eliminated as gas, vapor or feces, probably largely the latter, and the remainder, or one-fourth to one-fifth, is converted into somewhat permanent bodily substance.

Third, the under-fed nymphs seem to utilize their food somewhat more efficiently than do the individuals supplied with an amount of food more nearly adequate to realize the innate vital potentialities of the species. That is, the proportion of wastes to permanent bodily structures is greater in well-fed than in low-fed nymphs. As an illustration, note that eight bugs ingested 0.00727 gram in the course of their 9.0-day third instar: of this amount, an average of 73.15 per cent was expended, 26.85 percent converted into body. By contrast, 10 other bugs ingested 0.02063 gram during their third instar of 6.4 days: of this amount, 78.46 percent was eliminated, 21.54 per cent converted into body.

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THE ZOOPLANKTON OF CRAB ORCHARD LAKE DURING THE FIRST YEAR, 1941-1942

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Introduction

The dam at Crab Orchard Lake, east of Carbondale, Illinois, was first closed May 10, 1940, and completely filled February 1, 1942. W. B. Welch, of Southern Illinois University made periodic collections of the plankton from April 5, 1941 until April 3, 1942. He reported on the phytoplankton (Welch, 1942). Through his kindness, his collections were made available for the present study of the zooplankton. Thanks are due him for this and other favors and help, and to W. M. Gersbacher, of Southern Illinois University, for his advice and help.

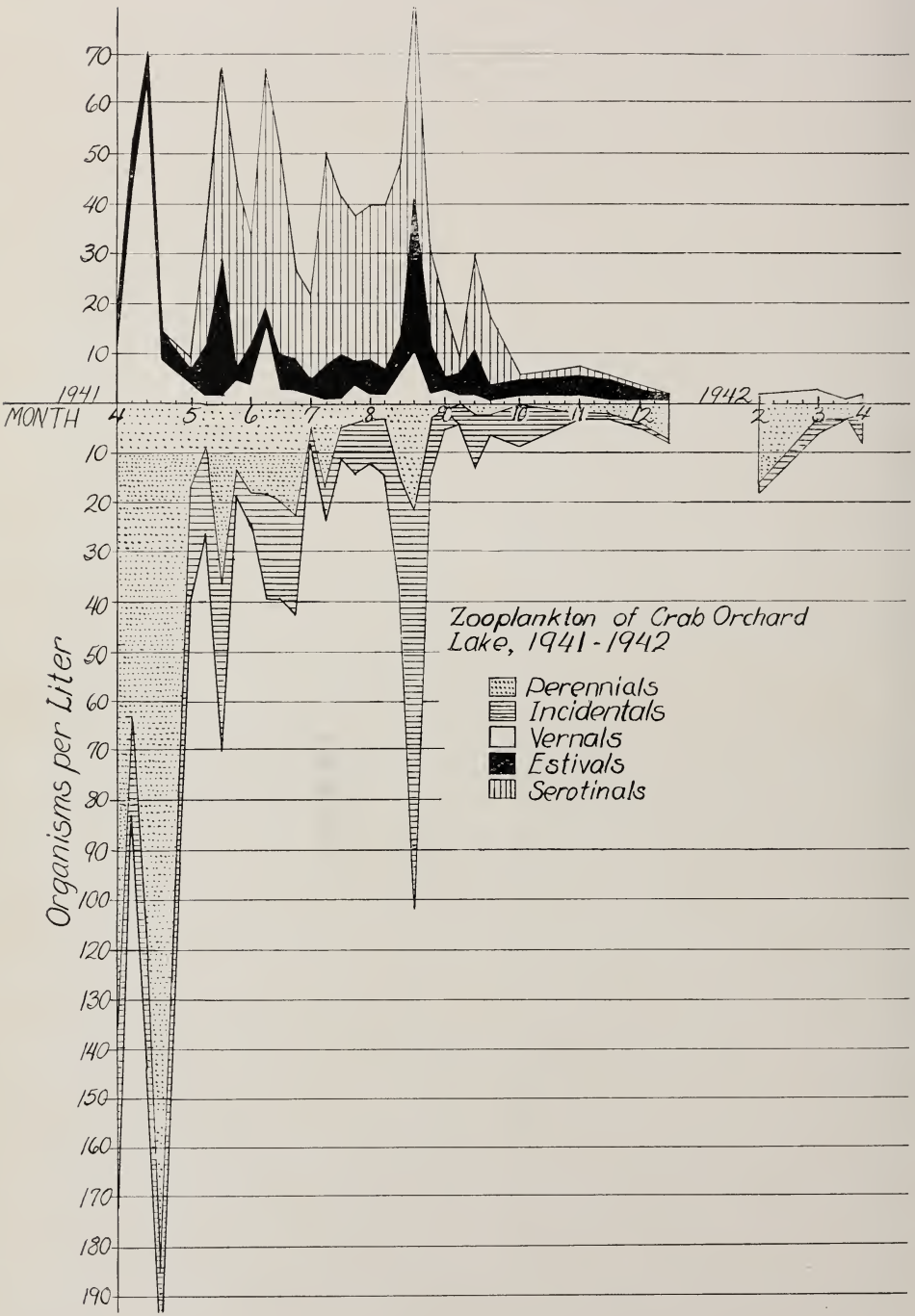
Fluctuations in Abundance

The great value of making frequent (weekly) collections during the spring, summer, and autumn is clearly shown in the accompanying graph. Several important fluctuations appear, which from their short duration could probably not have been discovered by collections at longer intervals. Notable fluctuations in abundance which occurred are described below.

(1) There was a great increase in numbers after the spring rains of 1941 had caused the surrounding lowlands to be flooded, and the subsequent aging of this new water. Large amounts of food materials were made available in the form of dead and decayed plants on the flooded lands. If the increase in numbers was actually caused by an increase of food supply, this organic debris must have been the source, since the plankton algae, which might have been a food source, showed no corresponding increase (Welch, 1942). Indeed, the only species of algae present in any quantity was a species of Asterionella. The other forms did not become abundant until later.

(2) A very sudden decline in population occurred after the early spring peak. This may have occurred as a result of the stagnation of the new water, and a decline in the amount of oxygen, or an increase in the amount of hydrogen sulfide, or a change in the pH. The decay of the organic debris in the water might have been the indirect cause of this decline through its effect on the factors mentioned. An examination of the data shows a very marked decrease in the numbers of individuals of most species in deep water after the first of June, when the general decline appears. It is probably in the deeper waters that a serious change in the factors mentioned would have had the most effect.

The increase and decrease described here are probably phenomena to be observed only in new lakes at the time of the first flooding, or other situations where a large amount of organic debris accumulates, as in lake bottoms which are exposed during long droughts. Eddy (1934) studied Lake Decatur in 1926, the second year after formation, and his graphs show no such increase or decrease, nor did it appear in the third or fourth years. There is no indication of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160
170
180
190
Organisms per Liter
Zooplankton of Crab Orchard Lake, 1941-1942
Perennials
Incidentals
Vernals
Estivals
Serotinals

this change in the few data available for the second year at Crab Orchard Lake.

(3) There were two sharp increases in abundance in mid-spring and late spring. Both increases were immediately followed by sharp decline.

(4) Beginning about the first of July, the population increased and was held at a generally high level until about the middle of August.

(5) A midsummer increase in abundance occurred about the middle of August. This increase was more pronounced than either of those of the mid or late spring, but was shorter in duration. It is notable that this increase occurred in nearly all species on August 22.

(6) The increase of August 22 was followed by a very sharp decline, which continued into the winter with late fall and early winter populations at a low level.

Seasonal Development

The present study is of value in that it shows the trend of invasion and development from the first formation of the lake. Even in this early stage, seasonal and perennial predominants appear. In general, the data presented in this paper seem to correspond closely to the perennial and seasonal groups reported by Eddy. In some cases, however, there are differences. Where these differences occur, it is assumed for the present that such differences are a result of the immaturity of the successional development, and are not real. In Eddy's collections, some forms appeared earlier than others, and frequently had a different seasonal development in the early than in the later stages. Eddy's listing of perennial and seasonal predominants is adopted here, even though there are some apparent discrepancies.

Perennials

Difflugia spp. Eddy lists *D. lobostoma*, and *D. globulosa*, both of which are probably present here, but it was not possible to make a consistent separation. A species is present which appears to be *D. urceolata*—Protozoan
Polyarthra trigla Ehr.—Rotifer
Keratella cochlearis var *macracantha* (Gosse)—Rotifer
Synchaeta spp.—Rotifer
Bosmina longirostris (O. F. M.)—Cladoceran

Vernals

Notholca sp. (*longispina* Kellicott?)—Rotifer
Cyclops bicuspidatus Claus—Copepod
Cyclops spp.—Copepod

Estivals

Filinia sp.—Rotifer
Conochiloides sp.—Rotifer
Daphnia longispina (O. F. M.)—Cladoceran
Diaptomus spp.—Copepod

Serotinals

Pedalia mira (Hudson)—Rotifer
Diaphanosoma leuchtenbergianum Fischer—Cladoceran
Ceriodaphnia lacustris Birge—Cladoceran
Ceriodaphnia sp. May be *Moina* listed by Eddy—Cladoceran
Ceratium hirundinella O.F.M.—Protozoan

Incidentals

Cathypna sp.—Rotifer
Monostyla sp.—Rotifer
Ratulus spp.—Rotifer
Noteus quadricornis Ehr.—Rotifer
Chydorus sphaericus (O.F.M.)—Cladoceran
Nauplius—Copepod

Plankton Community Development

Eddy (1934) considers the only permanent freshwater communities to be found in streams. These communities reach the highest development in physiographically mature streams. Impounded waters, as in

the lake at Crab Orchard, duplicate the conditions of a mature stream to an extent that causes the plankton development to resemble that of a mature stream. This appears to be true at least in the earlier stages, but in later stages, the impounded lake resembles an abandoned stream channel. As such, it forms a developmental stage in a land community.

The newly formed lake probably represents a secondary bare area, since many of the later predominant organisms probably are present in the original stream. Upon the sudden increase of space, at flooding, with the attendant increase of available food materials in the submerged land vegetation, the zooplankton experiences a sudden rapid increase, as suggested by the data here presented. Later, conditions become stable at a lower level of productivity, and new forms invade until the typical stream community is developed.

Eddy suggested that fresh water communities may show an associational difference. He found species of Brachionus to be prevalent in the waters he studied in southern Wisconsin and northern and central Illinois, but lacking in southern waters. The data studied here seem to corroborate his suggestion, since species of Brachionus were very poorly represented for a short time in the summer only. However, the data are not extensive enough to warrant any further discussion here on that subject.

Summary

This study of the net zooplankton of Crab Orchard Lake during the first year of filling before overflowing the spillway found a list of 21 genera with at least as many or more species of zooplankters. Seasonal aspect is developed, with a hiemal society absent or poorly developed, a poorly defined estival society, and well developed vernal and serotinal societies. A possible indication of the associational nature of stream communities is shown in the absence or scarcity of species of Brachionus, which is a predominant organism in more northern waters.

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A MOSQUITO SURVEY OF LAKE BLOOMINGTON*

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A survey was started in September 1946 to determine the species of mosquitoes and their possible breeding places at Lake Bloomington, Bloomington, Illinois. Although only occasional visits were made between the months of January 1947 and May 1947, a thorough investigation was made during the fall and summer months of the year 1946-1947.

Adult and larval stations were established at fifteen locations around the lake which covered an area of about twenty square miles. Parts of this territory are used for summer camps, and many permanent shore camps and homes have been erected around the lake. The banks and nearby shores are wooded, but farming areas surround the lake beyond the wooded area. It is from the draining of these fields and two large streams, Money Creek and Hickory Creek, that the lake receives the greater portion of its water supply. Generally the stations chosen were small streams which were formed by drainage ditches and ponds which were formed by backwater of the lake. Two of the stations were located at the edge of the lake. Although these stations by no means exhausted all of the breeding places of such a large area, they were typical of all of the places where mosquitoes might be found. The wooded area was inspected for possible breeding places of tree-hole species of mosquitoes. Culverts, bridges, and buildings used as dwelling places for campers and visitors to the lake were inspected for adult mosquitoes.

Larvae and pupae were collected by dipping and were brought into the laboratory for identification and rearing. Larvae in the second and third instar stages and pupae were reared into adults. Fourth instar larvae were mounted and identified.

The purpose of the survey undertaken at Lake Bloomington was to establish what species of mosquitoes were present in that area. Collections were made to determine the relative annual abundance of the various species with information as to breeding places and the extent of the control of the problem.

The larvae of *Anopheles quadrimaculatus* Say and *Anopheles punctipennis* (Say) were found in slow moving fresh water. At some stations these larvae disappeared when the water in the pools became stagnant during the summer drought. This was believed due to the stagnation of the water because at the same inspection time larvae were found in moving water a short distance from the pool. Adults of *A. quadrimaculatus* were located abundantly in culverts near streams where the larvae were found. The adults were collected in larger numbers than the larvae of this species.

Anopheles punctipennis has a variety of feeding places but prefers margins of pools and streams and edges of the lake. This species was found breeding at seven of the fifteen stations inspected. Although in most cases the water was moving slowly where they were found, at two locations the water had become

* This is an excerpt from a thesis presented in partial fulfillment for degree of Master of Science in Education at Illinois State Normal University, Normal, Illinois. The author wishes to acknowledge the counsel of Dr. Donald T. Ries under whom this phase of the work was done.

stagnated. The larvae were feeding on the algae which grows in the streams and ponds. Although this species was found in greater numbers in the larval stages, the *A. quadrimaculatus* outnumbered this species in the adult collections. Other species which were found in the adult stage included *Anopheles barberi* Coquillet, *Culex pipiens* Linneaus, *Culex restuans* (Theobaldi), *Culex apicalis* Adams, *Culex salinarius* Coquillet, *Aedes vexans* (Neigen), and *Aedes canadensis* (Theobaldi).

Of the genus Culex the species *C. apicalis* was found in greater numbers both in the adult and larval stages. This genus was found breeding in much the same waters as the *Anophelines* but at stations where water seemed most stagnant the *Culicines* persisted while the *Anophelines* died out. The species *C. apicalis* was found abundantly in all the stations inspected both in the fall of the year and summer. The larvae were more abundant than the adults. *C. salinarius* were found in very small numbers. This species was found in grassy pools. The larvae of this species were found at one station. *C. restuans* was found in the fall of the year in a pool that was littered with decaying leaves.

Of the genus *Aedes*, *A. vexans* was found more abundantly than the other species. The principal breeding places were temporary ruts that had filled with rainfall and grassy lands that contained a temporary water supply. The larvae of *A. canadensis* were found rather sparsely in the fall of the year and only at one station in the spring. This was the earliest species collected in the larval stage. The spring of 1947 was unseasonably cold thus limiting the development of other species. During a warm period in April this species was found in a grassy area where pools had formed from recent rainfall. The pools were small, but many larvae were present.

There has been no attempt in this survey to make a complete study of the mosquito problem at Lake Bloomington, since there was insufficient time to apply to the many problems to be solved. Due to lateness in starting the problem, the survey is incomplete for the month of August and nearly so for the month of September; thus leaving without inspection the two months in which the incidence of mosquitoes is highest. Tables were made giving a count of the relative abundance, and can be used as evidence of the predominance of different species. Only those which were brought into the laboratory for identification were recorded.

A list of the larvae collected in the order of their abundance:

Anopheles punctipennis
Culex apicalis
Aedes vexans
Anopheles quadrimaculatus
Aedes canadensis
Culex pipiens
Culex restuans
Culex salinarius

A list of the female and adult in order of their abundance:

Anopheles quadrimaculatus
Anopheles punctipennis
Culex apicalis
Anopheles barberi
Culex restuans
Culex pipiens
Culex salinarius

SEX AND THE ALTITUDE OF FLIGHT IN CYCLOCEPHALA

(Coleoptera: Scarabaeidae)[1]

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University of Illinois, Urbana

Several years ago (1941) I published in these *Transactions* a short discussion of the two beetles, *Cyclocephala immaculata* (Oliv.)[2] and *C. borealis* Arrow, as they occurred one year at Urbana. I had found that these insects were attracted to light traps in the ratio of 10.3 females to 1 male. This was just the reverse of the situation reported by Neiswander (1938) in Ohio, who had worked with *borealis* and found that, over the season, 7 males appeared in his traps to 1 female. Unfortunately, neither paper gave the height of the light traps from the ground.

My traps were suspended from telephone poles over the tops of apple trees at a height of 10 to 12 feet. In correspondence Neiswander informed me that his traps had been operated at a height of about 5 feet, and although his traps were rather low, on occasion he did get more females than males in a single night's collection, but that the sex ratio in recent years would probably run even higher than 7 males to 1 female. It may be that the occasional preponderance of females at the lower levels is due to a weather factor, somewhat similar to that observed by Wellington (1944) in the case of *Culex*.

Also in 1941 there appeared the study by Johnson of his work in Connecticut with *C. borealis*. Johnson, who stated that his traps were placed directly on the ground, found that the ratio of the sexes was 272.6 males to 1 female. He gave a description of the mating habits of the beetles, pointing out that mating takes place at dusk or at night, on or near the ground shortly after emergence from the soil. Hayes (1918) in describing the mating of *immaculata* said that it "takes place in the daytime [dusk?], and in life-history cages was several times observed on the surface of the soil." Ritcher (1944) has stated that the life cycle and biology of the two species are similar.

M. W. Sanderson made light trap collections at Fayetteville, Arkansas, in 1940, 1941 and 1942. His trap was hung between 7 and 8 feet high. He kept a record of all *Cyclocephala*, males and females separately, that were taken each night. The species of *Cyclocephala* collected was *immaculata* (with a very few *robusta* Lec.). In 1940 he operated the trap from June 19 to August 29 and took *Cyclocephala* between June 19 and August 17. In 1941, the only complete season Dr. Sanderson operated the trap, the operating dates were from April 11 to October 31 inclusive and *Cyclocephala* appeared from June 6 to October 1. During 1942 the trap was on from April 4 to August 28, and the beetles were taken between June 8 and August 19. In 1940 the sex ratio was 4.96

[1] Contributions from the Entomological Laboratories of the University of Illinois, No. 284. Published by permission of the Graduate College. I wish to thank M. W. Sanderson, Illinois Natural History Survey, for generous permission to use his unpublished data, and W. R. Horsfall, University of Illinois, for various suggestions.

[2] It appears that it may be necessary to call this species *C. tenuicutis* (Casey), as the true *immaculata* is said to be confined to the West Indies (see Arrow, 1947).

males to 1 female, in 1941 it was 3.01 males to 1 female, and in 1942 the ratio was 2.37 males to 1 female. Only the ratio for the complete season of 1941 is shown in the tabulation below.

When considered in relation to the elevation of the traps from the ground, these apparently divergent observations on the sex ratio of *Cyclocephala* in four localities indicate that there is a flight stratification of the sexes.

Thus we have a nice correlation between the height of the light trap and the ratio of males to females taken:

Place	Trap above ground (in feet)	Ratio of sexes		
		Males		Females
Conn.	1	272	to	1
Ohio	5	7	to	1
Ark	7-8	3	to	1
Ill.	10-12	1	to	10

It seems from what we know of the habits of these insects that the males begin emerging from the soil in advance of the females. Mating takes place as soon as the females appear near, at, or just above the surface of the ground. It may be that the males ordinarily restrict their flight to within a few feet of the ground in their search for the females, as Johnson (*op. cit.*) has reported that the males "usually fly from 1 to 2 feet above the ground," and also that the males seem more active in the mating behavior. After mating it may be that the females become more active and fly higher in a sort of dispersal flight. As the adults are believed not to feed, it could hardly be a flight to find food. I have checked many of the females taken at the 10-12 foot level, and all were found to be carrying eggs.

It is quite apparent that there is the likelihood of misleading results in the use of light traps for checking on the difference between sexes in altitude of flight where the species is strongly attracted to artificial light. We do not know that the two sexes are attracted equally. Hayes (1925) has noted that, in a related subfamily, the males of *Phyllophaga* are commonly considered to be more abundant at lights than the females. In his study this was found to be true in 19 species, while in 3 species the females were more common at lights than the males. Further, if the sexes were equally attracted to lights, and if there was a stratification in the flight of the sexes, the influence of light traps would upset the stratification to a greater or lesser extent. On the other hand we cannot ignore the distinct differences between these four *Cyclocephala* studies which were based on hundreds of specimens trapped.

We know little about how far these beetles can be attracted by a light. It may be only a short distance, and they may come into the effective range of the light in a hit or miss manner during a somewhat aimless flight.

To summarize, on the basis of four studies involving the use of light traps, there is evidence that (1) male *Cyclocephala* beetles tend to remain near the ground, while (2) the females tend to fly at a higher level, and (3) are probably not attracted to artificial light until some time after mating.

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ERRATA

"Additional Records of Illinois Mammals," R. M. Wetzel, Trans. Illinois State Acad. Sci. 40:228-233, 1947:

Lines 21 and 22, page 232, right hand column, under *Neotoma floridana illinoensis* Howell. Illinois Wood Rat, which read "*Alexander*—Horseshoe Lake (Olive Branch), 1 INHS." should read "*Union*—Wolf Lake, 1 (skin only INHS)."

CLARENCE BONNELL
1863-1947

MEMORIALS

CLARENCE BONNELL
1863-1947

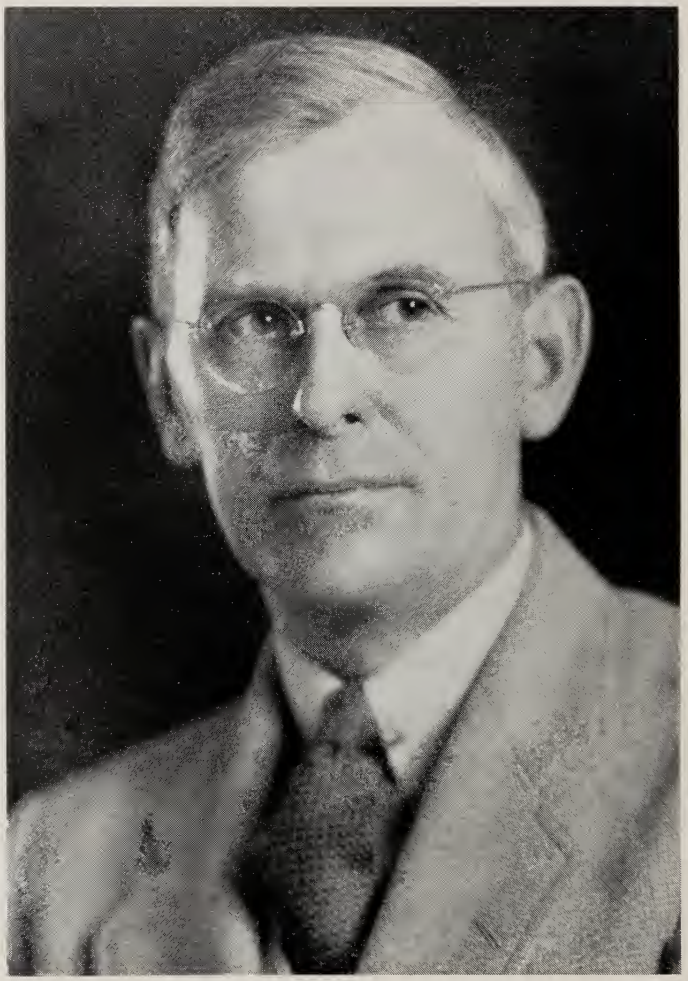
Clarence Bonnell, educator, naturalist, and author, was a native of Christian County, Illinois, and died June 21, 1947 at the age of 74 in Del Rio, Texas, of a heart attack while enroute home from the Rotary International Convention at Los Angeles.

Mr. Bonnell was for 43 years the assistant principal and head of the science department of the high school at Harrisburg, Illinois. He was president of the Salina County Historical Society, was a director of the Southern Illinois Historical Society, and a member of the Illinois State Academy of Science of which he was a past president. He was on the Board of Directors of the Friends of Our Native Landscape, 1927-30. He was also author of two books, "Little Journeys from Harrisburg," and "The Illinois Ozarks."

He was active in promoting State Parks in the southern part of Illinois and one of his greatest civic achievements was the long-time planning of a township park at Harrisburg which was built in an area made worthless as residential property by the subsidence of worked-out coal mines. This area, through his foresight, has been converted into a modern park with lagoons in the sunken areas and landscaped according to his proposals.

A son, Dr. Ellis Bonnell, of San Francisco, a psychiatrist who served as a medical officer overseas in World War II, and a daughter, Miss Mildred Bonnell, a food economist, who has just served with the UNRRA for two years in China, survive.

George D. Fuller



TERENCE THOMAS QUIRKE
1886-1947

TERENCE THOMAS QUIRKE

1886-1947

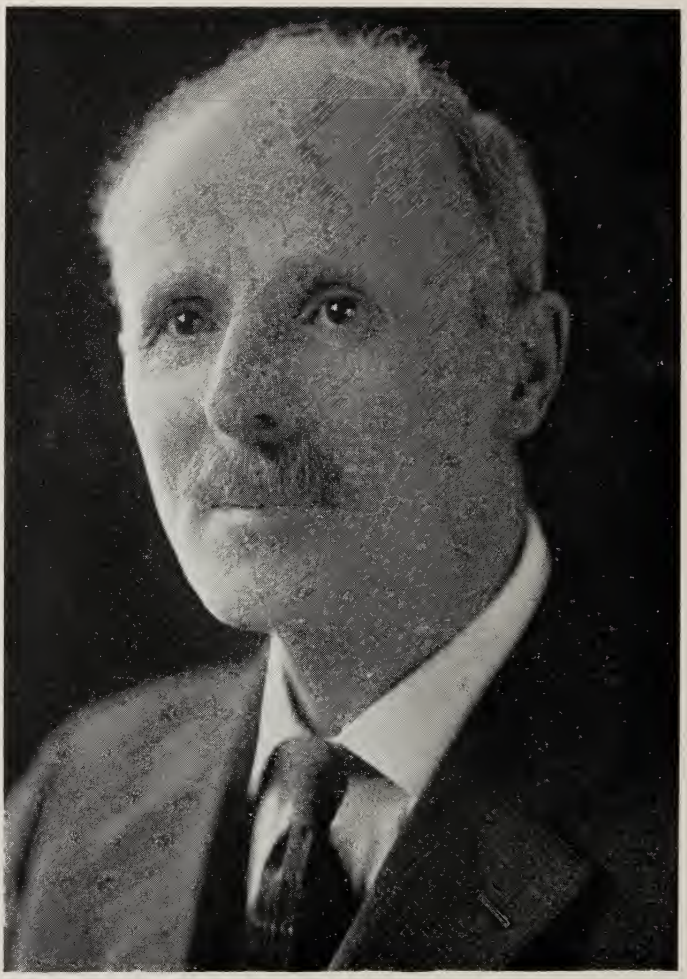
Terence Thomas Quirke was born at Brighton, Sussex, England on July 23, 1886. After secondary school training at Bancroft School, he came to the United States as a youth of 17 and attended the University of North Dakota where he graduated in mining engineering in 1912. He did graduate work at the University of Chicago, serving as research assistant to Professor R. D. Salisbury and completing work for the doctorate degree in 1915. While at Chicago Quirke started summer field work on the pre-Cambrian rocks of the Canadian shield for the Geological Survey of Canada, and continued in this field of research until 1931. Upon receiving his degree he accepted a position at the University of Minnesota, teaching structural, economic and field geology. In 1919 he was brought to the University of Illinois as chairman of the department of geology. He continued at Illinois until his death, serving as departmental chairman until 1928. His teaching covered engineering geology and mineralogy, petrology, structural and economic geology.

His Canadian research led to the discovery that the Huronian metamorphosed sediments north of Lake Huron seemed to grade eastward into granites which had been called Laurentian and considered much older than the Huronian. This discovery not only altered the correlation which had been made within the Canadian shield but it also suggested that large masses of granite may form by a process of granitization of pre-existing rocks. This concept has had much additional support in recent years and "the origin of granite" was the subject of a full day symposium before the Geological Society of America last Christmas. Other noteworthy contributions by Quirke were the developmen of an ingenious device for projecting optic figures, and researches in various titanium compounds. After the Geological Survey of Canada discontinued the employment of other than Canadian citizens in 1931, he took part in numerous investigations of mineral prospects in Canada, Vermont, Cuba and the southeastern United States. He was the author of 34 books, bulletins, journal articles and geologic maps.

He joined the Illinois Academy of Science in 1921, and presented five papers before the geology section at various meetings. He was chairman of the geology section in 1944-46 and a member of the research development committee. In addition he belonged to several other professional geological and engineering societies.

Quirke will be remembered for his great contributions to pre-Cambrian geology, for his interesting lectures, and for the high ethical standards which he impressed on the generations of young men students who came under his direction. He was active until the day of his death, having taught classes in the morning and attended a Rotary Club luncheon at noon that day, August 19, 1947.

Harold R. Wanless



THOMAS EDMUND SAVAGE
1866-1947

THOMAS EDMUND SAVAGE
1866-1947

Thomas Edmund Savage was born on a farm near Salem, Iowa, in 1866. His education included attendance at Whittier College, Iowa Wesleyan College, and the University of Iowa, where he received his bachelor's degree in 1897 and master's in 1899. He received the doctorate in geology from Yale in 1909.

He served as high school principal at Mt. Pleasant, Iowa from 1895 to 1896, and was professor of biology and geology at Western College from 1899 to 1903. He joined the staff of the Iowa Geological Survey in 1903, where he served as Assistant State Geologist until 1906. He came to the University of Illinois in 1906 as a member of the department of geology and for many years combined his teaching career with summer work on the Illinois Geological Survey which had been reactivated in 1905, only one year before Savage's arrival in Illinois.

Savage's field of research was the sedimentary rocks of the Paleozoic era and the life record revealed by their contained fossils. He concentrated especially on the rocks and faunas of the Silurian and Devonian periods, but also worked extensively on the Pennsylvanian. His classification of the Silurian and Devonian rocks of Illinois and their correlation with other areas has been the standard for the Mississippi Valley for many years. Although his field work was largely in the Mississippi Valley, one notable exception was his study of the rocks along the shores of Hudson and James Bays, Canada, in 1916.

In addition to his special stratigraphic and faunal studies Savage left a great monument to his career in reports on the areal geology of several counties in Iowa and at least ten quadrangles in Illinois with an aggregate area of nearly 2000 square miles.

Savage joined the Illinois State Academy of Science during its first year and regularly participated in its programs for many years starting with the second annual meeting. Altogether he appeared on the programs of 15 annual meetings. He was chairman of the geology section in 1931. He was also a member of many other professional geological societies and during his life published 69 papers.

For 28 years of active service he taught courses in historical geology, paleontology and stratigraphy at the University of Illinois. Many of his students now occupy prominent places in the geological profession. During his later years he became interested in the geologists' view of evolution and the relation between the evolutionary doctrine and religious faith. He believed that the acceptance of evolution was possible along with the retention of firm Christian faith and gave addresses and wrote articles on this theme. After his retirement in 1934 he was spared for 13 additional years during which his health permitted travel, community activity and geologic research. After a brief illness he died November 22, 1947.

He will be remembered as a kindly and scholarly teacher and as one who contributed much to unravelling the complex threads of the earth's past history.

HAROLD R. WANLESS

JOHN VOSS
1895-1948

JOHN VOSS
1895-1948

With the passing of John Voss, Peoria lost a beloved teacher and a good citizen, and Illinois lost a keen and hard working scientist. He was born in Peoria on December 24, 1895, and died at his home on March 20, 1948 after an illness of several months.

His early education was in the public schools of Peoria and in the Bradley Institute, and afterwards at Knox College, Galesburg, where he was graduated with the Degree of B. S. After teaching in Elgin, Roseville, and Arlington Heights, and serving for a short time in World War I, he returned to his native city and to its Manual Training High School where he taught biology and mathematics from 1924 to 1934.

He was appointed principal of Washington School in 1935, and in 1937 he became the principal of the Manual Training High School where he served until his fatal illness in 1947. Under his administration numerous improvements were made in this school.

Continuing his formal education, largely during his summer vacations, he entered the University of Chicago where he received the degrees of M. S. in 1925, and Ph.D. in 1933.

John Voss was a charter member of the Peoria Academy of Science, and gave it outstanding service from its organization in 1930. He served as Vice President, President, and as Director, and was elected to an honorary membership on February 10, 1948.

He was a member of the Illinois State Academy of Science from 1928 and was a regular attendant at its meetings. He served as Treasurer from 1937 to 1947.

As a scientist John Voss has made outstanding contributions to the past history of the vegetation of Illinois during the Yarmouth, Sangamon, and Early Wisconsin interglacial periods as revealed by his studies of the fossil pollen of the peat deposits in the state.

A thoroughly trained plant ecologist, John Voss carried his scientific spirit into his hobbies. He was a skillful photographer, and his flower photographs of the local flora have brought distinction to his community, and honorary mention in a national competition. He was a Fellow of the A.A.A.S, belonged to the Ecological Society of America, the Botanical Society of America, the Torrey Botanical Club, and was also a member of Sigma Xi.

John Voss will be remembered by his hundreds of students as a beloved teacher, by his acquaintances as a dependable friend, and by his fellow scientists for his modesty and his untiring pursuit of truth.

Dr. Voss is survived by his widow, Marie, a son Eugene J. Voss of Peoria, two grand daughters, and two brothers, Henry and Fred of Peoria.

GEORGE D. FULLER

ISABEL S. SMITH

1864-1948

Isabel S. Smith was born at Hillsdale, Michigan, on October 22, 1864, and died at Oberlin, Ohio on January 19, 1948.

After some years of teaching in high schools in Ohio, she became an Assistant in Botany at Oberlin College from which institution she was graduated with the degree of A. B. in 1901. In 1903 she went to Illinois College at Jacksonville, Illinois where she remained for 24 years, advancing from the rank of Instructor in Biology to that of Professor of Botany and Dean of Women. During her stay at Illinois College she found time for further study at the University of Chicago from which institution she was granted the degrees of M. S. in 1905 and of Ph. D. in 1922.

She was a charter member of the Illinois State Academy of Science in 1907 and soon became a life member. She was Vice-President of the Academy in 1919. She was also a member of the Botanical Society of America.

Upon her retirement from teaching at Illinois College in 1927, she made her home at Oberlin, Ohio, where she was made assistant Curator of the Herbarium of Oberlin College, an activity that she maintained for many years.

She was an efficient teacher, a close friend of all her students and a botanist who knew the plant life of the community in which she lived.

George D. Fuller

ACADEMY BUSINESS

SECRETARY'S REPORT ON THE BUSINESS OF THE ILLINOIS STATE ACADEMY OF SCIENCE

For the Year May 3, 1947 to May 8, 1948

Compiled by Hurst H. Shoemaker, *Secretary*

The loss to the academy in the death of Dr. John Voss, Treasurer, on March 20, 1948 was great. Dr. W. W. Grimm, who had so generously assisted in the work during the illness of Dr. Voss, was appointed to serve out his term of office.

The academy held its 41st annual meeting in Benton on May 7 and 8. There were 134 papers presented in the 10 senior and 2 collegiate sections to a record attendance of 500 persons. The annual banquet speaker on Friday evening was Kenneth A. Reid, Executive Director of the Izaak Walton League, who spoke on "Land and Water Management in the Public Interest." Eugene S. Richardson, Jr., of the Chicago Natural History Museum, spoke Friday afternoon before 350 Junior Academy members on "Major Features of Earth Structure." On Saturday more than 100 persons took part in biological, geological, industrial, and archaeological field trips.

1. COUNCIL MEETINGS

There were four council meetings during the year. At the first meeting, May 3, 1947 in Peoria, Illinois, Clarence Bonnell's invitation to hold the next annual meeting in Harrisburg was accepted. Because of Mr. Bonnell's death during the summer, the question of a meeting place was re-opened.

At the second meeting in Urbana, October 25, 1947, with President Stover presiding the council accepted an invitation extended by Mr. B. Floyd Smith to hold the annual meeting in Benton. Dr. Neil Stevens and Editor Rose presented reasons why the publications committee was unable to carry out the council's decision at Peoria to print in the Transactions abstracts of papers not accepted for full publication. As a substitute, for this year, the council voted to print brief abstracts of all papers in this year's program. When it was learned how much higher the printing costs would be than anticipated, a quick poll of the available council members was taken and a substitution was made. This was to suggest that chairmen of each section mimeograph the abstracts and distribute them at the annual meeting. Because of the general increase in prices and the fact that our dues had remained at the original one dollar for 40 years, the council voted to circulate the membership on the question of an increase in dues.

President Stover called the third council meeting which met in Urbana, January 17, 1948. The meeting was devoted largely to plans for the annual meeting. Dr. Mills offered the services of the Natural History Survey in conducting the biological field trips. The council unanimously voted to sponsor the recordings of the "Science on the Air" programs which they hoped would be financed by the University Extension.

President Stover presided at the fourth council meeting held in Benton, May 6, 1948. The council approved the ranking of the papers for publication by the sections and left the method of ranking to the section chairman. The council unanimously passed a motion to combine the committee on science talent search selection with the committee on science talent search scholarships. Consideration was given to the appointment of a permanent publicity chairman, but action was deferred. A motion was passed that the Council recommend an increase in annual dues to $2.00 to be voted on at the business meeting the following day.

2. GENERAL BUSINESS MEETING

A short preliminary business meeting was held at 9:30 a. m., May 7, 1948, at which appointments were made to committees on nominations, resolutions, auditing, and necrology. At the second business meeting held at 5:00 p. m., reports were heard from the acting treasurer, the editor, and chairmen of the committees on auditing, conservation, resolutions, necrology, and nominations. It was announced that Knox College, at Galesburg had invited the Academy to hold its next annual meeting there.

REPORT OF TREASURER

For the Year May 1, 1947 to April 30, 1948

Receipts

Balance on hand April 30, 1947		$ 1,537.69
Dues and initiation fees:		
Annual members	$ 725.00	
Life member	25.00	
Affiliated societies	11.00	
		761.00
Interest on Forbes and Meyer real estate		18.00
Interest from U. S. Savings Bonds		5.00
Sale of Transactions		3.10
Sale of reprints		97.65
Libraries		7.00
Research Grant by the A. A. A. S.		408.00
Junior Academy:		
Dues	$ 1.00	
Sustaining memberships	10.00	
		11.00
Total Receipts		$ 2,848.44

Expenditures

Council dinner and breakfast—Peoria	$ 67.00
Local Chairman's expenses—Peoria	66.53
Section Chairmen's expenses	12.60
Treasurer's office expenses	14.50
Secretary's office expenses	4.17
Editor's expenses	17.00
Librarian's expenses	59.80
Transporting Transactions—2 years	9.35
Corporation registration	1.00
Conservation Council	3.00
Printing	228.25
Secretary, honorarium	125.00
Editor, honorarium	150.00
Research grants—C. W. Bennett, $75.00; W. M. Reid, $75.00; H. F. Thut, $50.00; Sr. M. Joan, $83.00; P. E. Martin, $125.00	408.00
Flowers for Dr. John Voss	10.85
Junior Academy	83.38
Total Expenditures	$ 1,260.43
Less Outstanding Checks	423.57
	$ 836.86
Balance in Commercial Bank of Peoria	2,011.58
	$ 2,848.44

Statement of Resources, April 30, 1948

Balance in the Commercial Bank of Peoria	$ 2,011.58
Certificate of interest for Meyer Block Leasehold	Value Unknown
Certificate of interest for Forbes Building	Value Unknown
United States Savings Bonds, Series G	200.00
Total Resources	$ 2,211.58

The membership of the Academy consists of 61 life members, 97 new annual members, 17 sustaining members, 509 members paid up to and including the year 1948, 214 members one year in arrears, 42 members two years in arrears. The total membership is 843. During the year 14 members have resigned, 4 were deceased and 35 moved, leaving no forwarding address.

Respectfully submitted,
JOHN VOSS, Treasurer (deceased)
W. W. GRIMM, ad interim Treasurer

REPORT OF THE COMMITTEE ON AUDITING

To the Illinois State Academy of Science:

Your committee on auditing respectfully submits the following report:

We have examined the records of the Treasurer, John Voss, and the ad interim Treasurer, W. W. Grimm, for the year May 1, 1947 to April 30, 1948, and find them correct. The present financial status of the Academy is as follows:

Cash on deposit with the Commercial National Bank of Peoria	$ 2,011.58
Series G, U. S. Savings bonds two	200.00
Meyer Block Leasehold Certificate No. 15 (value unknown)	0.00
Forbes Building Certificate No. 13 (value unknown)	0.00
Assets	$ 2,211.58
Less outstanding checks	423.57
Real Assets	$ 1,788.01

(Signed) A. G. ADAMSON, Chairman
E. SCHOENBECK
L. P. ELLIOTT

REPORT OF COMMITTEE ON RESEARCH GRANTS

Following is a list of projects approved by the Committee on Research Grants:

William M. Bailey Southern Illinois University, 506 S. Popular, Carbondale, Ill.	$ 60.50
Bernard Greenberg Roosevelt, Chicago 5, Ill.	25.00
J. V. Karabinos St. Procopius College, Lisle, Ill.	45.00
R. Maurice Myers Western Illinois State College, Macomb, Ill.	40.00
James M. Sanders Chicago Teachers College, 6800 Stewart Ave., Chicago 21, Ill.	45.00
Sister M. Christine Mundelein College, Chicago 40, Ill.	45.00
Total	$ 260.50

(Signed) J. W. NECKERS,
Acting Chairman,
Research Grants Committee

REPORT OF COMMITTEE ON RESOLUTIONS

RESOLUTION No. 1

WHEREAS the Illinois State Museum is performing a valuable educational function both by its instructive exhibits in its present location, and also by numerous loan exhibits circulated through the schools of the state; and

WHEREAS it is obvious that the present quarters of the museum are excessively cramped, inconveniently located, and altogether inadequate for the proper performance of its useful purposes; and

WHEREAS the Illinois State Legislature has already appropriated funds for the acquisition of a site for an adequate museum building, and for the preparation of suitable plans for such a building; and

WHEREAS the plans now drawn up for the new building have received wide praise from museum people over the nation, and the execution of these plans would provide the citizens of Illinois with what would probably be the most effective, though not the most costly, state museum in the country;

THEREFORE, the Illinois State Academy of Science reaffirms its approval and

support of this museum building project, and resolves to take such steps as seem appropriate, to acquaint the governor of the state and other executive and legislative officers, that would be in position to cooperate, of its conviction that they will serve the best interests of the state by appropriating adequate funds at an early date for the erection of the proposed museum building.

Resolution No. 2

Whereas, the State of Illinois is known to contain small natural areas distinct and precious by reason of their unique ecological features and rare species of plants and animals, and

Whereas, these areas are too small for inclusion in the State Park System as now visualized, and

Whereas, these areas are threatened with impairment or destruction by the inroads of industry, agriculture or other developments, therefore

Be It Resolved, that the Council of the Illinois Academy of Science refer to the proper committee of the Academy the question of (1) finding some administrative state agency interested in the acquisition of such widely separated areas, (2) proposing some way of administering and protecting them, and (3) devising some method of selecting deserving sites, formulating specifications which the sites should meet, and assuring that the purpose for which the sites are set aside be actually preserved.

Resolution No. 3

The Illinois State Academy of Science, at its annual business meeting held at Benton, Illinois, May 7, 1948, voted to favor the establishment of a permanent nonpartisan Conservation Commission of the State of Illinois.

Resolution No. 4

The Illinois State Academy of Science is pleased hereby to express its appreciation to the Benton Chamber of Commerce, the Board of Education, the Superintendent of Schools, Mr. B. Floyd Smith and his committee on local arrangements, the Benton Baptist Church, and to any other persons or groups who served in any way to provide housing, meeting places, projecting equipment, excellent musical entertainment, direction and transportation on field trips, and other services and equipment necessary to the happiness of members and visitors and to the success of the annual meeting of the Academy held at Benton, Illinois, May 7 and 8, 1948.

Resolution No. 5

Resolved, that the Secretary of the Illinois State Academy of Science write a letter of appreciation to Mrs. John Voss, Mrs. Ethel Schoenbeck, and Dr. Wilbur W. Grimm, all of Peoria, Illinois, for their valuable assistance to Dr. John Voss in the management of his work as treasurer of the Academy during his illness in the past year, 1947-1948.

Resolution No. 6

Resolved, that the Secretary of the Illinois State Academy of Science is hereby directed to write a letter to Mr. Robert Ingli, Director of Visual-Aids, Southern Illinois University, Carbondale, Illinois, expressing the appreciation of the Academy for his indispensable services in providing and setting up projectional equipment required in the presentation of lectures and papers at the annual meeting of the Academy held at Benton, Illinois, May 7, 1948.

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STATE OF ILLINOIS

ADLAI E. STEVENSON, *Governor*

TRANSACTIONS

OF THE

ILLINOIS STATE ACADEMY OF SCIENCE

VOLUME 42 1949

Forty-Second Annual Meeting

Galesburg, Illinois

May, 1949

PRINTED BY AUTHORITY OF THE STATE OF ILLINOIS

ILLINOIS STATE ACADEMY OF SCIENCE

AFFILIATED WITH THE

ILLINOIS STATE MUSEUM DIVISION, CENTENNIAL BUILDING

SPRINGFIELD, ILLINOIS

DECEMBER 31, 1949

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(1) Any organization, institution, or individual who wishes to get the current *Transactions* must become a member of the Academy by payment of the annual dues.

(2) All previous volumes or portions of volumes containing scientific papers can be purchased for the amount of the current Academy dues. Address orders or payments to:

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Illinois State Academy of Science,
Bradley University, Peoria, Illinois.

(3) For possible exchange privileges, write to:
Director,
Illinois State Museum,
Springfield, Illinois.

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STATE OF ILLINOIS

ADLAI E. STEVENSON, *Governor*

TRANSACTIONS

OF THE

ILLINOIS STATE ACADEMY OF SCIENCE

VOLUME 42 1949

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ILLINOIS STATE ACADEMY OF SCIENCE

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ILLINOIS STATE MUSEUM DIVISION, CENTENNIAL BUILDING

SPRINGFIELD, ILLINOIS

DECEMBER 31, 1949

STATE OF ILLINOIS
ADLAI E. STEVENSON, *Governor*

DEPARTMENT OF REGISTRATION AND EDUCATION
NOBLE J. PUFFER, *Director*

ILLINOIS STATE MUSEUM DIVISON
THORNE DEUEL, *Chief*

ILLINOIS ACADEMY OF SCIENCE

AFFILIATED WITH THE

ILLINOIS STATE MUSEUM

OFFICERS, COMMITTEES AND DELEGATES

1948-1949

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SECRETARY, HURST H. SHOEMAKER, University of Illinois, Urbana.
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The ACADEMY COUNCIL consists of the officers named above, the two most recent past presidents:
ERNEST L. STOVER, Eastern Illinois State College, Charleston.
LEO R. TEHON, Illinois State Natural History Survey, Urbana.
Past Secretary:
HURST SHOEMAKER, University of Illinois, Urbana.

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Geol.

David Lansden, Cairo.
Morris M. Leighton, State Geological Survey, Urbana.
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L. F. Gumbart, Macomb.
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ECOLOGICAL BIBLIOGRAPHY: Arthur G. Vestal, Chairman, University of Illinois, Urbana.

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Robert L. Smith, Herrin High School, Herrin.
Audrey H. Lindsey, University High School, Urbana.

187.61, Ser. 2, Vol 42, Dec., 1948

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CONTENTS

PAGE

ADDRESSES

PATON, R. F., Available Energy 9
SANFORD, CHARLES W., The "Who" in the High School Science Program 12
SPALDING, WILLARD B., Training of Teachers for Tomorrow's World 21

PROGRAM

Papers Presented at the 42nd Annual Meeting 30

ARCHAEOLOGY AND ANTHROPOLOGY

GILLETTE, CHARLES E., Late Woodland occupations of the Fisher Site, Will County, Illinois 35
SCHOENBECK, E., More data on Hopewell sites in Peoria region 41

BOTANY

BAILEY, WILLIAM M., Initial report of the vascular plants of Southern Illinois 47
FELL, EGBERT W., and GEORGE B. FELL, Ferns of Rock River Valley in Illinois .. 56
KAEISER, MARGARET, Embryo development of the pond cypress (*Taxodium ascendens* (Brongn.) 63
FULLER, GEORGE D., EGBERT W. FELL, and GEORGE B. FELL, Check list of the vascular plants of Winnebago County, Illinois 68

CHEMISTRY

SISTER MARY MARGUERITE CHRISTINE, B.V.M., Place of science in general education 80

GEOGRAPHY

GARLAND, JOHN H., Occupance of the Mississippi border of Southern Illinois 85
SMITH, L. MARJORIE, The pulp and paper industry of the Lake states 91

GEOLOGY

GROGAN, ROBERT M., Present state of knowledge regarding the pre-Cambrian crystallines of Illinois 97
KNODLE, ROBERT D., Factors affecting measurement of permeability of unconsolidated glacial material 103
LOWENSTAM, HEINZ A., Facies analyses of the Niagaran rocks 113
SHRODE, RAYMOND S., Physical characteristics of the oölite grains of the Ste. Genevieve formation 116

PHYSICS

CONKLIN, RICHARD L., Investigation of a gamma-proton process in beryllium ... 120
ROBERTS, HOWARD C., and RICHARD E. WENDT, Electronic aids to control and measurement 123
SILKETT, A. F., and MAE A. DRISCOLL, Simple circuit for measuring variations in electrical resistance of a human being under emotional stress 128

SOCIOLOGY

HOUSER, FRANK E., The structure and institutionalization of a protest group ... 130
TUDOR, WILLIAM J., Southern Illinois—a cultural area 140

ZOOLOGY

PAGE

BLACK, JOHN D., Changing fish populations as an index to pollution and soil erosion 145
BRAUN GARWOOD A., and GEORGE I. DYNSTRA, A survey of the Unionidae of the upper reaches of the Mackinaw River 149
GOLDBERG, ROBERT J., Notes on the biology of a common gastrotrich of the Chicago area 152
MITTLER, SIDNEY, Genetic variation in populations of *Drosophila Melanogaster* in the Chicago area 156
NELSON, RUSSEL E., Incidence of Trypanosoma infection in small mammals of Champaign County, Illinois 159
WALTON, A. C., Parasites of Ranidae (Amphibia). XIV 161

COLLEGIATE SECTION

REID, W. MALCOM, SHIRLEY JEAN NICE, and RHODA COOPER MCINTYRE, Certain factors which influence activation of the hexacanth embryo of the fowl tapeworm *Raillietina cesticillus* 165

MEMORIALS

CHARLES TOBIAS KNIPP 169
MARGARET ENGSTROM 171

ACADEMY BUSINESS

Secretary's Report for 1948-1949 173

ROBERT F. PATON, *President,* 1948-1949

PRESIDENTIAL ADDRESS

AVAILABLE ENERGY

R. F. PATON
President, Illinois State Academy of Science

There is much current writing and discussion about energy and, in particular, the atomic and nuclear variety. Concerning the concept of energy, there is some careless thinking and frequent misconception. For we live in a universe filled with many different forms of energy which are never destroyed but which may be transformed. When energy is needed for any purpose, it must be supplied in a form suitable for the job intended. It is customary to think of such energy as available energy and to ignore other forms as if they did not exist, simply because they are not available.

To illustrate this, consider the immense amount of energy in an ocean. Such a supply is usually thought of as heat energy. Some of this energy goes to melt icebergs; is replenished by absorption of light from the sun; but cannot be used to propel a boat. To be available to operate a boat, the energy must be at a higher temperature than the ocean. Hence, the energy from burning fuel is available, in part at least, to drive the engine in the boat.

Fuel energy available for heating and for operating engines has been stored in the earth by plants and the like, having originally come from the sun. The sun sends out energy at such a tremendous rate that if all that strikes the earth could be retained and stored, there would be enough in a few weeks to equal all that stored as gas, oil, coal, and oil-shale over the millions of years that the sun has been shining on the earth. This seems surprising, but plants are very inefficient at trapping and storing solar energy, yet no other general means has ever been devised. Solar energy is given off by our sun, whose effective surface temperature is about 6000°C. This is almost too hot to be used in an engine, but is so very diffuse that only about 2 calories per square centimeter per minute is received from the sun at the earth.

To be available, energy must have appropriate temperature and concentration. In an engine, temperatures as high as 2000°C can be readily managed. Higher temperatures soon become troublesome, for there are no satisfactory materials for building engines which will be durable at such temperatures. Energy coming from known chemical reactions can maintain temperatures of a few thousand degrees. In internal combustion engines, turbines, and rockets, such energy is used for propulsion or transformation into electrical form.

Suppose Q_1 to be the heat of some chemical reaction in some mixture

such as a hydrocarbon and oxygen. This energy may be thought of as a quantity supplied to an engine. Receiving this energy allows the engine to do an amount of work, W. A large part of Q_1 is, however, always discarded, as hot gases for instance in an internal combustion engine, and also in cooling devices designed to assimilate the discarded part of Q_1 under circumstances as favorable as practicable. Calling the discarded energy Q_2, the law of conservation of energy—also known as the first law of thermodynamics—says that

$$Q_1 = W + Q_2 \qquad (1)$$

When fuels are burned in a furnace and used for heating, Q_1 is evolved at say 1500°C, W is zero, and Q_2 is equal to Q_1, appearing as heat at the temperature level desired, say 20°C. Q_1 is available for use as heating energy only if its temperature is above 20°C. All the heat in the ocean cannot supply even heat to a boat unless the ocean temperature is higher than that desired in the boat. It is a characteristic of all heat energy that it cannot, of itself, flow uphill in temperature. This, in a superficial way, is a statement of the second law of thermodynamics.

The process suggested in equation (1) is not an entirely reversible process. However, heat to an amount Q_2 can be taken out of the inside of a refrigerator, for example by supplying an appropriate amount of work W with a motor or some equivalent device. The result of this process is

$$Q_2 + W = Q_1 \qquad (2)$$

The heat Q_1 is rejected by the hot coil of a refrigerator to its surroundings while Q_2 is removed from the inside. Q_1 is greater than Q_2 by an amount W. Equation (2) gives, in principle, the heat pump. In winter, for instance, Q_2 may be taken from the water in a deep well, an amount W added to it with a suitable motor, and the entire amount Q_1 used to heat the house. The only part of this energy which is supplied by a commercial fuel is W. Since Q_2 types of heat energy are available in essentially limitless supply, great savings on the more costly type of energy, represented by W, can be accomplished by using sources whose supply of Q_2 is almost available.

In the ideal engine, it is possible to get work W from heat Q_1 to an amount

$$Q_1 - Q_2 = W \text{ where } \frac{Q_1}{Q_2} = \frac{T_1}{T_2} \qquad (3)$$

T_1 and T_2 are the absolute temperatures of the hot, Q_1, source and the cold, Q_2, source respectively. Any actual engine will not do as well as equation (3). The efficiency of an engine is given by

$$\frac{W}{Q_1} = \frac{Q_1 - Q_2}{Q_1} < \frac{T_1 - T_2}{T_1} \qquad (4)$$

In a case where fuel maintains T_1 at say 10,000°K (K = °C on absolute scale) and a cooler takes rejected heat at 500°C, the efficiency will always be less than $\frac{10{,}000 - 500}{10{,}000} =$ 95 percent but may approach this 95 percent in an ideal case. (See equation 4).

This brings us to the atomic problem. In the bomb, temperatures of 100,000,000°K are probable. But the efficiency of an engine run by such energy will be conceivably equal to

$$\frac{100{,}000{,}000-500}{100{,}000{,}000} = 99.9995 \text{ percent}$$

at best. This is very little better than the 95 percent efficiency. Further more, there is no material for construction which will hold together at even the 10,000°K. To use atomic nuclear energy, massive installations are necessary to lower the temperature of this energy to below the 10,000°K level before it can be used for practical purposes. Only a very few processes above the 10,000°K level are of any interest to the everyday world. One of these, the destruction by atomic bomb, we almost wish had never been discovered. Mankind lives at around 300°C. Processes involving energy at temperatures far from this value are dangerous and apt to be highly destructive. They are the really unavailable types of energy.

There is a vast supply of energy just below the 300°K level in this earth everywhere about us. Using a heat pump, it is quite possible to make this energy available, and increasingly engineering is making it practical to utilize this energy for heating purposes. The plant which traps solar energy in fuel form maintains itself in this earth at suitable temperature and in a very real sense is able to trap the solar energy in a usable form. Solar energy traps designed to bypass the plant will surely use the heat pump also, for the solar energy comes from such a high temperature source that, to a large percentage, it may be thought of as a *W* form and is correspondingly useful if sufficiently concentrated.

The only practical advantage of nuclear energy is that it can be tremendously concentrated, though so far the process has been tremendously expensive. New processes unknown and unimagined as yet must be discovered if the possibilities of nuclear energy which can be associated with temperatures above 10,000°K are to prove useful. These energies will then be "available" in the usual sense.

MORNING ADDRESS

THE "WHO" IN THE HIGH SCHOOL SCIENCE PROGRAM*

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All of you are aware of the structure of the Illinois Secondary School Curriculum Program. It is sponsored by the State Superintendent of Public Instruction, Vernon L. Nickell, in cooperation with colleges and universities and 38 lay and professional organizations. Among the cooperating organizations are the Illinois Association of Chemistry Teachers, represented by T. A. Nelson of LaGrange, the Illinois Association of Teachers of Biology, represented by J. S. Tucker of Centralia, and the newly organized or re-organized Illinois Council of Mathematics Teachers represented by Miss Gertrude Hendrix of Eastern Illinois State College.

Numerous unanswered questions regarding "The Who in the High School Science Program" and other similar items were largely responsible for the decision by the steering committee of the Illinois Secondary School Curriculum Program that assistance and encouragement should be given to every participating school and community to get the facts about itself that are basic to curriculum revision. The committee correctly insisted that we have, for too long, made curriculum changes on the basis of hunches or as a result of super-salesmanship by someone.

The implementation of this decision to ferret out the facts called for the structuring of a series of local factual studies designed to locate answers regarding "Who?", and in addition, "What?", "When?", and "How?". Four studies concerned largely with the "Who?" and "What?" were variously conducted in 135 Illinois high schools during the past year.

Before turning to an analysis of these studies, it may be apropos to state that we are not unmindful of the many accomplishments of our schools. The high schools have increased their holding power; virtual equality obtains among the educational opportunities afforded to boys and girls and men and women; teachers are better trained; physical plants have been improved; better textbooks are available; improved instructional equipment is used, including many audio-visual aids; the instructional program has been enriched by the addition of work in such areas as health, physical education, art, music, agriculture, home economics, work experience, social and personal relationships, and conservation; advances have been made in relating the subjects taught to

* Portions of this article are quoted from the following reference: Sanford, Charles W. "Challenging Developments in the Illinois Secondary School Curriculum Program", *The Bulletin of the National Association of Secondary-School Principals"*, Volume 33, Number 162, April, 1949, p. 57-65.

life; and education is now generally looked upon as a continuous process lasting throughout life, with few persons regarding education as completed when a certain age has been reached.

These accomplishments, and others which might be cited, show that change is possible. All of us are well aware of the forces that have operated in producing these changes; moreover, all of us realize that many of these same forces, and others, are presently pointing to the necessity for further changes. These accomplishments demand our admiration, but we must, if we are realistic, look long and hard at certain problems that now obtain and at certain facts which we now have.

One such problem is this: "Is the holding power of our schools satisfactory in terms of accepted democratic goals?" Let us look first at some national figures.[1] For every 1000 pupils in the fifth grade in 1932-33, 786, or about 78 per cent, entered the ninth grade in 1936-37. Thus, our 4-year high school consisting of grades 9-12 had no chance at all to work with 22 per cent of the youth of high school age. Of the original 1000, 664, some 66 per cent, found their way into the tenth grade; 570, or 57 per cent, entered the eleventh grade; 510, 51 per cent, started the twelfth grade; and 455, approximately 45 per cent, were graduated. Certainly we can clearly see in these data substantiation for Provost Griffith's recent statement that American education ". . . has given too little to too few." Of the original 1000 fifth grade pupils 160, or 16 per cent, entered some college and 47, about 4 per cent, were graduated in 1944.

In the belief that national figures of this type ordinarily do not, and should not, convince persons connected with a local school that its holding power is deficient, the steering committee for the ISSCP decided to conduct a holding power study in a number of Illinois schools. The committee correctly reasoned that evidence must be obtained regarding local withdrawals if reasons for these withdrawals are to be examined and corrected. As a consequence, during the past year, a holding power study was conducted in 76 representative Illinois high schools. Three assumptions underlay this study:

1. That the secondary school is expected to serve all the children of all the people, and that the school can serve most adequately those children who are in school.

2. That the types of children who have dropped out of school in the past are the types most likely to drop out in the future, if present practices remain unchanged.

3. That the school, by changing its practices, can influence children to remain in school.

In each school, information was obtained to help us determine what proportion of all enrollees dropped out of school, at what times they dropped out, and what kinds of students they were in terms of such factors as economic status, I. Q., school success, course of study pursued, extent and nature of participation in extra-curricular activities, distance of the home from the school, behavior problems, and out-of-school

[1] Statistical Summary of Education, Ch. I, U. S. Office of Education, Biennial Survey of Education, 1942-44, p 31.

employment. Perhaps it is significant to note that all of these 76 schools had stated that they wanted to participate in this study. This same policy operates in all phases of the ISSCP. The program is in every respect voluntary; a school may participate or not, as it wishes.

Our composite findings from this study revealed that in Illinois boys dropped out in larger proportions than girls; that almost all of the drop-outs were receiving, when they withdrew, very low marks; that children from lower-income families dropped out in much larger numbers than those in the middle- and upper-income groups; that there was no appreciable difference in the holding power of small and large high schools, and so on. They also revealed that while Illinois schools have a better holding power than was cited for the country as a whole, there is still much to be done to increase holding power in Illinois. The range in drop-outs was from less than one to as many as eight for every ten who were graduated. On the average, for every ten who received diplomas, approximately three had dropped out. Since the study included only those pupils who started in the ninth grade, we can safely say that, for every ten who were graduated, considerably more than three youths of secondary school age were not in school. These state-wide summaries and others, together with data for each local school, have been returned to participating schools for use in the formulation of hypotheses regarding local curriculum changes which may lead to an increase in holding power. Certainly the data for each school furnish convincing evidence regarding vulnerable points for intensive study looking toward promising change.

With these drop-out figures for Illinois and the United States before us, let us look at the picture in science. Three sources provide a fairly good picture, though we must say that the picture needs to be defined even more clearly. First, we cannot offer high school science to youth who are not enrolled in any type of private or public secondary school.

The national picture was presented earlier. It indicated that, in round numbers, between 30 and 40 percent of the youth of high school age are not in school, and as a consequence, are receiving no instruction in science. "In 1940-41, the best year of our history as far as high-school enrollments are concerned, only 73 per cent of our youth of high-school age were enrolled in high schools."[2]

In addition to these data and those presented for 76 high schools in Illinois, we might look at the summaries in the annual statistical reports of the Office of the Superintendent of Public Instruction. They indicate that during the year of July 1, 1939 to June 30, 1940,[3] there were 103,239 pupils in the fifth grades of our public schools; in the period of July 1, 1946 to June 30, 1947,[4] there were 62,841 in the twelfth grades. Thus, 40,398 were lost between the fifth and the twelfth grades.

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[2] *Life Adjustment Education for Every Youth.* Federal Security Agency, U.S. Office of Education, Washington, D.C., 1948, p. 11.

[3] *Annual Statistical Report of the Superintendent of Public Instruction,* State of Illinois for the Year Ended June 30, 1940. Office of the Superintendent of Public Instruction, Springfield, Illinois, No. 328, p. 252.

[4] *Annual Statistical Report of the Superintendent of Public Instruction,* State of Illinois for the Year Ended June 30, 1947. Office of the Superintendent of Public Instruction, Springfield, Illinois, Circular Series A, No. 47, p. 352.

Second, a random sample of 114 Illinois public high schools ranging in size from 32 to 2,018, with a proportionately larger number of schools included below 250, in accordance with the proportion which obtains between small and large high schools in Illinois, indicated that in 1947-48, 19 percent of all high school students were taking general science, 19 percent biology, 6 percent physics, and 7 percent chemistry. The population of these 114 schools was 27,878, approximately 9 percent of those attending all Illinois public high schools.

Third, college-bound students probably take more work in science than those who do not enter some university. In an effort to discover how many students entering the University of Illinois had completed courses in science in high school, a study was made of the high school records of 100 students who entered the University in September 1948. Of this group, 63 had completed one unit in biology; 70, one unit in physics; 62, one unit in chemistry; and 80, one unit in some other science, usually general science. Thirteen students had completed a total of one unit in science; 28, two units; 31, three; and 28, four. The average number of units of science taken by these 100 students was 2.74.

These data indicate clearly (1) that all of us are confronted with a major task in trying to keep in school a larger proportion of the youth of secondary school age and (2) that all of us need to examine very critically our present science offerings, especially the work in the 9th and 10th grades. Is the traditional course in general science adequate for the large number who will receive no more? If not, what should be offered? How may we be reasonably sure that what we propose is adequate? Certainly all of us will take every step within our power to decrease the number of drop-outs; but while we are doing so, we have to be realistic and work with what we have.

Let us look at both of these questions. It was stated earlier that many Illinois high schools are attempting to increase their holding power through self-study projects followed by the testing of locally formulated hypotheses. One of these projects was concerned with the question, "Are the costs connected with certain phases of the school's program depriving some youth of the very experiences they need?" Also, we might ask whether or not the facts indicate that costs are the cause of some of our drop-outs. Many Illinois high schools attempted to obtain, during the past year, the facts concerning the identity and the amount of the full range of these costs. For want of a better name we called them "hidden tuition costs." Our composite findings in 79 representative schools, and here I am including grades 7-12, indicated that science textbooks were most commonly rented to pupils, that pupils purchased their books in from about a third to somewhat over half of the schools, and that it was only in the two lower grades, grades 7 and 8, that over 10 percent of the institutions provided free textbooks. Two out of every five high schools required eleventh and twelfth grade pupils to pay a special fee, assessment, or deposit in science courses, but this practice was much less fre-

quent at the lower grade levels. From about two-thirds to over nine-tenths of the schools, depending upon the grade level of the course, required pupils to purchase special materials or items of equipment in science. The median costs to pupils who attended schools in which textbooks were purchased by the pupils was $2.50 for seventh grade science, $2.40 for eighth grade science, $3.10 for ninth grade science, $3.90 for tenth grade science, $3.60 for eleventh grade science, and $3.75 for twelfth grade science. The lowest costs reported were nothing in grades 7, 8, 9, 10, and 11, and $0.50 in grade twelve. The highest costs to pupils who attended a school in which textbooks were purchased by the pupils was $2.76 for seventh grade science, $2.90 for eighth grade science, $3.85 for ninth grade science, $7.50 for tenth grade science, $6.60 for eleventh grade science, and $10.25 for twelfth grade science. The median costs of belonging to the biology and science clubs were $2.50 and $1.25, respectively; the highs were $7.50 and $39.90 respectively. Similar data were obtained for all subjects and extra-class activities offered in these schools.

Obviously, these state-wide summaries have relatively little significance except as they may serve as a basis for comparisons and as they may serve to stimulate local investigations leading to adjustments and corrections. Each school, then, must analyze the implications of cost facts of the type mentioned. Do high costs lower the holding power of the school? Do the costs of certain activities and of certain subjects mean that some pupils who need those activities do not participate in them? If so, how can we answer the charge that the school is not serving equally well all of the children of all of the people? One of my colleagues at the University of Illinois, Professor Harold C. Hand, has very neatly pointed, in the following words, to answers for these questions:

1. The school is by definition an *educational* institution.
2. As such, it cannot legitimately permit, much less sponsor, any activity (whether class or extra-class, formal or informal) which is not educative in nature.
3. If the activities permitted or sponsored are educative in nature, no public school in a democracy can justify making the accident of birth in an economic (or any other) sense determine who shall and who shall not benefit from said educative activities.[5]

Next, let us examine briefly the questions posed earlier, namely, "Is the traditional course in general science adequate for the majority who will receive no other work in science?" "If not, what should be offered?" "How may we be reasonably sure that the 'what' we propose is adequate?" Means are suggested for obtaining answers to these questions in the *Guide to the Study of the Curriculum in the Secondary Schools of Illinois.* I quote from the *Guide.*

The first and most fundamental policy being followed in the ISSCP is that curriculum improvement is a *grass roots* job, that any changes which may take place should be the result of the work of teachers, administrators, and lay persons in local schools. Although consultants from outside local schools will be available to provide assistance as needed, the real source of power in the operation will come from local schools rather than from outside.

[5] Hand, Harold C., *Principal Findings of the 1947-1948 Basic Studies of the Illinois Secondary School Curriculum Program.* Circular Series A, No. 51, Illinois Secondary School Curriculum Program Bulletin No. 2, Office of the State Superintendent of Public Instruction, Springfield, Illinois. May, 1949, p. 64.

The purpose of the school is to provide learning experiences so that the needs of youth and the requirements of society may be met effectively. The means of accomplishing that end, that is, the selection of what learning experiences may best meet youth and societal needs, constitutes a basic task of curriculum makers.

Curriculum construction might, therefore, be viewed in part as a sifting process wherein a selection from all possible learning experiences is made. What youth need and what society seem to require may constitute the sieve. All of the accumulated social and cultural heritage is available to those who teach. The teacher must select those experiences which will be most profitable to youth and adults.

Since all youth have certain needs in common and the social setting presents certain requirements common to all citizens in a democracy, a portion of the school day may be devoted to these "common learnings" of all youth. This would not change the policy of providing a wide offering of other subjects on an elective basis.[6]

The *Guide* suggests certain basic needs of high school youth, and it presents several statements of the purposes of the high school. In the Follow-Up Study which is presently underway in 100 high schools, we have defined 55 problems of high school youth which stem from these needs. Needs, purposes, and problems must be considered, but they only introduce us to the "specifics" to be used in the classroom. Certainly the introduction is a basic one, but it points only to the kinds of pupil activities which go on in the classroom. At this point we have found that the consultants from the colleges and universities who are cooperating with the Illinois Secondary School Curriculum Program render their greatest service.

[6] Houston, Victor M., Sanford, Charles W., and Trump, J. Lloyd, *Guide to the Study of the Curriculum in the Secondary Schools of Illinois.* Circular Series A, No. 51, Illinois Secondary School Curriculum Program Bulletin No. 1, Office of the State Superintendent of Public Instruction, Springfield, Illinois. August, 1948, pp. 9 and 10.

At the present time, as most of you know, the ISSCP is cooperating with 33 selected school systems in attempting to develop 58 projects. These projects are concerned with the improvement of existing courses in English, mathematics, science, social studies, etc.; with enrichment in broad fields; with development of common learnings courses; and with projects which cut across subject lines.

The ISSCP does not suggest any one type of curriculum improvement project as best for a given school. Decisions of this type should be made by teachers, administrators, and others working together to improve the curriculum in local schools. Each school is encouraged to start where it is, with what it has, and on that in which it is vitally interested.

A team of consultants from the colleges, universities, State Department, and other high schools cooperate with persons affiliated with local schools in attempting to develop superior programs. If and when superior programs have been developed, the local teachers and administrators will help other schools on similar projects. Moreover, as the local projects are being developed, teachers and administrators from other schools are encouraged to study what is going on.

The findings from the basic studies conducted in these schools are of inestimable value in building a broadly based local concensus regarding what needs to be done and in furnishing numerous "specifics" which merit attention.

It would be premature, after only one and a half years of work, to try to relate many of the emphases and

re-directions that are taking form in these projects. However, several have become crystal clear. They are:

1. The energies of our faculties and of others who are interested in secondary education must be directed toward meeting more adequately the needs of all youth, not the needs of one or two or three groups of youth.

2. In those schools in which developmental projects are underway, emphasis is being placed on real-life problems.

3. Whenever such problems are stressed, we find in the schools more and more emphasis on good work habits, how to work with others, understanding ourselves, developing a zeal for the democratic way of life, conservation, health, problems of community, state, national, and international concern, and the choice of appropriate school subjects.

4. Whenever such problems are stressed we also find more and more attention given to sharpening the guidance program to the end of identifying as early as possible the interests and abilities of students so that there may be provided learning experiences which will be of greatest value.

I wish that time permitted a development of this problem as it relates to locating youth with superior abilities, keeping them in school, and providing curricular experiences of maximum value.

5. It is becoming increasingly obvious that curriculum change is a "grass-roots" proposition. Persons from outside a given school system may be ready and anxious to cooperate with local schools, but little is accomplished unless the dynamic for local projects obtains within the local group.

6. Curriculum work which is effective calls for a high order of cooperation. At the local school level, this cooperation means participation by many members of the faculty; ideally, by all members of the faculty. It also means participation by school board members, by parents, by laymen who are not parents, and by pupils.

7. I hope I am correct in the observation that the schools, at least most of them, which have developmental projects underway have agreed that meeting the needs of all youth of secondary school age becomes a reality only when those concerned are obsessed with the notion that *all* youth of high school age are the business and concern of the high school. We must accept this notion or face the alternative. The alternative is that we shall let some other agency assume a part of the responsibility—another NYA perhaps.

Another study in the series sponsored by the ISSCP was concerned with the question, "Are pupils in our high schools participating in extracurricular activities according to their needs, interests, and abilities?" Do certain factors operate which make participation selective in one or more respects?

In the study which we conducted, we related extent of participation with sex, age, grade in school, location of school, mode of transport, acceleration-retardation, and socio-economic status. The data were then analyzed on the basis of each of the factors noted. The only factor identified which was associated with the number of participations was socio-

economic status, the accident of birth in an economic sense.

In all types of participation, there was less participation by children from low income families, somewhat more by children from middle income families, and by far the most by children from upper income families.

A fourth study was concerned with the problem, "Are the available guidance services both adequate and effective?" In all, or nearly all, schools some pattern of organized personnel services has been developed for students. These services may be concerned with the educational, occupational, social, and personal adjustments of young people.

Our investigation was carried on in 96 schools. We used three instruments, namely, the *North Central Association Check List of Elements in a Minimum and an Extended Program of Guidance and Counseling,* the *Illinois Revision of the Kefauver-Hand Guidance Test,* and the Ross L. Mooney *Problem Check List.* Our findings indicated that the major concerns of girls were in the area of Personal-Psychological Relations: "Losing my temper," "Nervousness," "Worrying," "Can't make up my mind about things," "Can't see the value of daily things I do," etc. The boys were most concerned with problems of Adjustment to School Work: "Taking wrong subjects," "Not getting studies done on time," "Worrying about grades," "Slow in reading," "Trouble in using the library," "Can't see that school is doing me any good," etc. Both boys and girls were bothered about problems concerned with Curriculum and Teaching Procedures: "Dull classes," "Made to take subjects I don't like," "Poor place to study at home," "Textbooks hard to understand," "Teachers too theoretical," "Wanting subjects I'm not allowed to take," etc., as well as problems concerned with The Future—Vocational and Educational: "Needing to decide on an occupation," "Not knowing what I really want," "Concerned over military service," "Deciding whether or not to go to college," etc. Typically, twelfth grade pupils exhibited about 75 percent knowledge of vocational trends and of the nature of the work involved in a sampling of representative occupations and a 67 percent knowledge regarding unfounded beliefs which lead to unfortunate vocational and educational choices.

So much for the 1947-48 studies which were variously conducted in 135 high schools. Copy for the inventories, tests, and schedules for conducting each of these studies has been set up in manual form. The manuals will be available on or about June 1.[7]

A fifth study in the series of studies basic to curriculum improvement, the Follow-Up Study, was initiated on February 15, 1949.

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[7] Allen, Charles M., *How to Conduct the Holding Power Study.* Circular Series A, No. 51, Illinois Secondary School Curriculum Program Bulletin No. 3, Office of the State Superintendent of Public Instruction, Springfield, Illinois. May, 1949.

Hand, Harold C., *How to Conduct the Hidden Tuition Costs Study.* Circular Series A, No. 51, Illinois Secondary School Curriculum Program Bulletin No. 4, Office of the State Superintendent of Public Instruction, Springfield, Illinois. May, 1949.

Hand, Harold C., *How to Conduct the Participation in Extra-Class Activities Study.* Circular Series A, No. 51, Illinois Secondary School Curriculum Program Bulletin No. 5, Office of the State Superintendent of Public Instruction, Springfield, Illinois. May, 1949.

Lovelass, Harry D., *How to Conduct the Study of the Guidance Services of the School.* Circular Series A, No. 51, Illinois Secondary School Curriculum Program Bulletin No. 6, Office of the State Superintendent of Public Instruction, Springfield, Illinois. May, 1949.

This study is concerned with two problems, "How may we build a strengthened teacher-pupil-school-patron consensus regarding the 'need-meeting' function of the secondary school?" and "How may we appraise the extent to which the local school is, or is not, now meeting the real-life needs of its secondary-school youth?" The five instruments, each of the check-type, which were designed for use in this Follow-Up Study, and which are now being used in 100 schools, focus attention upon 55 real-life problems of youth variously subsumed under the categories of "Earning a Living;" "Developing an Effective Personality;" "Living Healthfully and Safely;" "Managing Personal Finances Wisely;" "Spending Leisure Time Wholesomely and Enjoyably;" "Taking an Effective Part in Civic Affairs;" "Preparing for Marriage, Home Making, and Parenthood;" and "Making Effective Use of Educational Opportunties."

Teachers, pupils, parents and laymen who are not parents are asked anonymously to indicate whether or not the high school should help pupils with each problem cited. If the response is in the affirmative, they are asked to state how important it is for the school to provide such help. Teachers are also asked to evaluate the extent to which they believe graduates typically received help on each problem. Graduates are requested to indicate which of the problems they are experiencing, how much of the help they needed for each problem they obtained in high school, and how effectively they believe they are meeting each problem.

In closing, I should like to state that the Illinois Secondary School Curriculum Program is truly grateful to the Academy for the attention it is giving in this program, and through other activities, to the improvement of the high school science program. Many of the findings that I have reported this morning are discouraging, but of this I am sure—if we all work together and cooperate with the teachers of other instructional areas—the situation will improve rapidly.

EVENING ADDRESS

TRAINING OF TEACHERS FOR TOMORROW'S WORLD

WILLARD B. SPALDING
University of Illinois, Urbana

Many persons in the profession of training teachers do not like to have the word "training" used to describe their activities. It is, however, an old term that has been used for decades. Currently many persons are endeavoring to replace it with the word "education." They do this because they see some connotations in the word "training" which they do not like, particularly when they think of training an animal or training an athlete. They think of a seal clapping his fins or of a boxer beating down an opponent. Neither idea seems to be related to the activities of the teacher in the classroom.

Before abandoning a long-used and well-understood term, we should look at some of the connotations of the substitute. An "educated" person is one who, in the common parlance, knows a lot about a lot. He is a person who has read widely, traveled widely, and experienced much. His skills are many, but rudimentary. He is somewhat of a dilettante.

A "trained" person is educated, of course, but he is also able to integrate his knowledge and his experiences around a single purpose. If he is a doctor, he integrates his knowledge toward curing the ills of the body. If he is an engineer, he integrates his knowledge toward the design and construction of machines, of structures, or of roads. This connotation of integration of knowledge to an end makes it important to retain the old term and to speak always of training teachers as we would speak of training any other professional person.

Change Inevitable

I have used the term "tomorrow's schools" because education inevitably looks ahead. The child who enters kindergarten in September of 1949 will graduate from high school in 1962, and from the university in 1966. What kind of world lies ahead of him? What problems must he solve when his schooling is ended? These are important questions for all of us, but especially important for those who train teachers.

Changes take place rapidly. There are great advances in technology. During the period of 16-17 years that lie ahead before the beginning kindergartener takes his place in adult life, a lot is going to happen. We can see this most readily by looking at the past before we look at the future.

We can go back to 1932 and compare what happened then with what happens now in 1949. There has been great development in electronics. Radar can detect mobile objects in the air and has many other uses. Television is just beginning to

have its impact upon American life. Great mathematical problems which could not be solved within available time are solved by so-called mechanical brains. All of these changes centering around electronics have taken place within the 17 years that have elapsed since 1932.

In the area of transportation, streamlined trains, just beginning to be heard of in 1932, are now common. There are new airplanes, like the flying wing, with jet propulsion engines that were not even widely developed in laboratories 17 years ago. Trains and trucks use the diesel engine which was not adapted for such use until recently.

In the area of communication, "Pocket Books" sell widely throughout all parts of the nation. We have seen the growth and development of picture magazines, the coming of age of talking pictures, and a beginning use of facsimile reproduction. These are but a few of the changes in material things which have affected our way of living.

In organized society, since the early days of 1932, there has come the growth of social security, old age pensions, the rise of the unions to power, and open attacks by governmental agencies on intolerance and prejudice. Our age is characterized by increased use of government in an increasing number of areas of human endeavor. Government yardsticks, for example, have been set up to measure private industry. Government planning enters more and more into the control of our physical environment and the direction of our activities as citizens.

These are the things which have gone on, but they tell us little about what changes lie ahead. The rate of both social and technological change is something like a geometric progression. The more that man knows about the physical nature of the universe, the more he can find out. The more and better material things he creates, the more he can create. The more that man improves his relationships with his fellows, the more he can do to improve them.

Attitude Toward Change

Man cannot predict exactly what is going to happen, but he can be sure that there will be tremendous speeding up in both technological and social change. He can also state with some certainty that the rate of technological change will continue to be somewhat greater than the rate of social change. The problem of lag in adaptation of our society to technology becomes increasingly acute. Man is reluctant to change his accustomed ways of doing. He doesn't seek to change his relationships to his government or to unorganized groups of his fellows with anything like the degree of eagerness with which he seeks to change his automobile when a new model comes out. He is reluctant to believe that the increasing speed of technological change makes social change not only inevitable but desirable. When he does begin to understand the need for social change, he does not translate his understanding into action.

As man observes the world, it is soon clear to him that there are competing systems of ideas about what is good in government, in the production of material things, and in the use and ownership of them. Ideas are not destroyed readily. The conflict of ideologies which exists today will continue through at least the

two decades which lie before us. It may differ in the degree of intensity with which it is carried on. It may change its nature somewhat, as new ideas come into the picture, but the conflict will remain.

Rapid technological change and rapid social change will be taking place in an atmosphere which is charged with the emotions arising from ideological conflicts. In the midst of the maelstrom sits the modern American, bewildered by what goes on and attempting to prevent many things from h a p p e n i n g. Change seems to him to be undesirable. He tends to resist it at every turn.

One of the great problems for education is the development of a generation of persons who understand that change is ordinary, who recognize that change is inevitable, who begin to examine their environment and to initiate changes in order to improve it.

One result of man's fearful attitude toward change is a change-resisting school rather than a school which facilitates changes. One of the major reasons for the critical social lag is the vicious circle in which one change-resisting generation makes the schools produce another change-resisting generation, which in turn prevents the schools from changing. Schools must recognize that a major responsibility is the development of an intelligent attitude toward change among their students, and this is not accomplished by teaching which reverently adheres to traditional, rote memorization procedures which fail to provide many opportunities for problem-solving.

Role of the Teacher

What is the role of the teacher in such a school? The teacher is several persons in one. First, he is a part of the environment of the children who attend school. His personality impinges upon the personalities of his students each day. What he does, what he is, what he thinks, how he dresses, how he appears, what he feels, and all of the other facets of his personality affect the way in which children learn what they learn.

In the second place, the teacher is a manipulator of the student's environment even while he is a part of it. He arranges the time of day at which each activity takes place. He selects and uses printed materials, pictures, and visual aids. He plans the emotional climate of the classroom. He decides whether there are to be democratic, autocratic, laissez faire, or some other kind of relationships.

In the third place, he is a scholar of the nature of society. He understands both social trends and social development. He sees cause and effect at work in human relationships and understands how to bring about the effects he desires. He is a student of the internal dynamics and structure of organized and unorganized groups of persons. He understands the ways in which governments operate.

In the fourth place, he is a scholar of the nature of man. He knows how man learns. He understands the physiology of human growth. He knows the relation of physiological readiness in learning. He understands the way in which attitudes, appreciations, and emotions are de-

veloped; in short, he understands with considerable thoroughness the human animal with which he deals.

In the fifth place, he is a professional person in a difficult area. The problems of the teacher are far more intricate and complex than those of any other profession. A human being cannot be placed in a test tube or a betatron and examined. He cannot be planted in the soil so that his growth and development can be watched. Whatever is done to him in order to observe him, changes him while the observing takes place. No technique can be used for long, because he adapts to it.

So it is with methods of teaching. It is extremely difficult to know what method of teaching is best in a given situation, and having found the method, it soon becomes obsolete. Man is an adaptive animal. Whatever is done to him leads to changes in his behavior so that he can escape from the doing. What is a good method with the student today may be a poor method with him three years later because he has learned to adapt to it. The teacher, as a professional, must know the methods which look to be good at the time that he is trained. He must also be versed in the procedures whereby he can invent better methods when he finds that familiar ones no longer work in practice.

Youth's Basic Needs

Unless the teacher may be characterized in these ways, he will achieve comparatively little success in helping *all* youth of secondary school age meet the sorts of basic needs which are outlined in the *Guide to the Study of the Curriculum in the Secondary Schools of Illinois*. An examination of any one of these youth needs will illustrate the complexity of the teacher's job. The fifth need cited is:

> Acquiring knowledge of, practice in, and zeal for democratic processes:
>
> a. Learning to be intelligently critical of the social heritage.
>
> (1) Possessing an understanding of and belief in our culture.
>
> (2) Being able to gather the facts regarding society and evaluating them.
>
> (3) Developing ability to be independent in arriving at judgments; must not merely imitate a teacher or leader.
>
> (4) Being able to propose a plan and see the consequences if the plan is adopted.
>
> b. Seeing and utilizing opportunities for participation in community activities outside of the school.
>
> c. Achieving appropriate understanding of and relationships with minority (or majority) groups.
>
> d. Developing an understanding of the necessity for international peace together with some knowledge of how to further it.
>
> e. Understanding relationships between the sciences and human destiny.

Training the Science Teacher

The scientists of America have studied the problem of training the science teacher. Their report was published in 1942. Participants in the project included the National Committee on Science Teaching, the American Council of Science Teachers, the American Association for the Advancement of Science, the American Chemical Society, the American Nature Study Society, the National Association of Biology Teachers, and several other scientific groups.

In discussing aspects of our present culture, their report states:

> There is likely to be little disagreement with the statement that our culture is witnessing one of the most rapid developments and changes in the history of Western civilization. There can be no quarrel with the proposition that

science—invention and technology—has been largely responsible for this unprecedented growth. Almost overnight, it seems, we have been whisked from an age of agrarianism and simple capitalism to an age of industrialism and corporate ownership. The change has been so rapid that we have not yet developed a terminology suitable for discussing with facility the new order of things. . . .

It is not to be wondered at, therefore, that there are at present many divergent ideologies. Nor is it surprising that men of science are becoming self-analytical, that scientists are attempting to develop critical philosophies, to understand the potentialities inherent in the methods and accomplishments of science. They recognize a responsibility, not only for their own immediate discipline, but also for the employment of their discoveries in the betterment of man's lot. . . .

Meanwhile the youth of today is facing a wor'd of contradictions—of want in the midst of plenty, of fear in an age of potential security, of greed and selfish interest in a society supposedly influenced by the ethics of Christianity, of class stratification and restraint of human rights in a political democracy, and of wars and recurring crises in the "scientific" twentieth century. It is amid these confusions that the teacher of science must help young people solve their problems.

Aims of General Education

After describing these problems of our culture, the scientists then look at the problem of training a teacher, first, as an individual and a citizen:

The teacher is first of all a person. To the extent that he is intelligent, informed, conscious of social issues, and happily adjusted in his life and his views, he may become an outstanding teacher. This is true for all teachers regardless of field, and it should be noted that the general education proposed in this chapter is thought of in terms of *all* teachers and, for that matter, of all persons living in a democracy. But it seems especially important that those accepting the responsibility for giving science instruction be provided with this education.

The prospective teacher should acquire a sufficient range of understanding to insure his social acceptance in the community where he teaches. He should merit recognition as a person generally well informed and should be able to accept and handle a position of responsibility in the community.

He must have avocational interests and the ability to enjoy and appreciate a variety of intellectual and aesthetic pursuits. He must understand human beings, their customs, and their institutions, and recognize the roots of local prejudices and provincial mores in biological and cultural variants. To work effectively and sympathetically with community problems, he will need to recognize institutions in relation to their origins and in comparison with the similar and the greatly different institutions which have obtained in other times and places. And, above all, he should have had the advantages of guidance and study to aid him in the development of a personally and socially satisfactory conception of life.

I. THE TEACHER SHOULD HAVE AN UNDERSTANDING OF AMERICAN CULTURAL GROUPS. The American science teacher lives and works in the midst of a cultural complex composed of many shifting socio-economic, racial, ethnic, national, and religious groups. In times of crisis, intolerance, misunderstanding, and fear arise among cultural groups and these stresses are seized upon by demagogues and those seeking to further special interests. America, as well as Europe, is faced with fallacious doctrines and common misunderstandings regarding the superiorities or inferiorities of various groups. Most of these conclusions disregard the fact that range of individual difference within any population is demonstrably great with respect to almost any character; that to think of all individuals in terms of an average or in terms of other individuals is almost certain to result in error. Such conc'usions convey the idea of political or racial units all of whose members possess given charcters.

II. THE TEACHER SHOULD UNDERSTAND THE VARIATIONS IN INSTITUTIONAL FORMS OF PAST AND PRESENT SOCIETIES. Today, more than ever before, it is imperative that those responsible for the education of youth defend and expand democracy and aid in actualizing our democratic vision. The science-trained teacher will recognize that the American forms of life can best be defended on the basis that they are operating in such ways that we de-

rive satisfaction, security, and personal and national well-being from them. Furthermore, they should be inspected and modified on the pragmatic basis of how well they are functioning, or can be made to do so, for the wellbeing of the nation and its individuals. . . .

III. THE TEACHER SHOULD UNDERSTAND THE POTENTIAL RELATION OF SCIENTIFIC RESEARCH TO DEMOCRACY. Society has already become so integrally scientific in the material sense that the expression, *impact of science on society*, is nearly meaningless. There is no aspect of human activity that organized science has not modified; but intellectually, we can hardly be called scientific. In large part science has remained subordinate to private interest and is called upon to do its part but to remain in the background; it is the indispensable handmaiden of our industrial expansion but could hardly be said at present to be offering intellectual direction to society commensurate with its potentialities.

IV. THE TEACHER SHOULD UNDERSTAND HIMSELF AND HIS STUDENTS, THEIR PARENTS, AND OTHERS IN THE COMMUNITY. That understanding of human beings is necessary for success as a teacher is a proposition likely to encounter little opposition. Basically it is the theme of every section in this chapter. This understanding is in part a background of general understanding of human beings, their characteristics, their development, and the factors which influence these. In part it is an understanding by the teacher of himself and the individual children and adults with whom he works.

V. THE TEACHER SHOULD DEVELOP LEISURE-TIME ACTIVITIES AND AESTHETIC SATISFACTIONS. It is the belief of the Subcommittee that the problems of leisure-time activities and the goal of developing aesthetic satisfactions should be more carefully considered in the education of teachers. The Subcommittee agrees with the statement that 'the word *(aesthetic)* should not only apply to something that happens in museums.'[1] Many take the position that teachers should have contacts with, and develop appreciations and abilities in, various areas of aesthetics. The National Survey of Education of Teachers revealed that only about one third of the teachers from teachers' colleges, liberal arts colleges, and universities had had any work at all in the fine arts in either high school or college.[2] Appreciation and creative ability in the arts need not, of course, originate or develop within the confines of institutions, but the establishments of early contacts may engender the development of appreciations and abilities which would otherwise remain dormant.

VI. THE TEACHER SHOULD DEVELOP A SATISFACTORY CONCEPTION OF LIFE. Many adolescents pass through a period of adjustment and orientation among conflicting religious and ethical concepts. Emotional disturbance often results when an individual experiences apparent contradictions between the faith to which he has clung and the logic that is associated with science. It seems important that the teacher, particularly the teacher who deals with the subject matter and the method of science, should be aware of the perplexities that exist in the minds of young people, and should develop for himself a consistent and workable philosophy of life that will enable him to give sound guidance and counsel to those in his charge.

These are the six aims of general education which scholars from scientific societies believe should become part of the aims for preparation of teaching of science. They should become part of the aims for the preparation of teachers for almost any field.

General education is related to the first aspect of being a teacher—that of being a part of the environment of the children in school, of being a personality which impinges at each moment upon the personalities of students. This education will enable them to develop the personalities which will be most helpful to them as individuals and citizens, and most wholesome for the students with whom they work.

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[1] Progressive Education Assn., Commission on Secondary School Curriculum. *Science in General Education*, p. 126. D. Appleton-Century Co., New York, 1938.

[2] Evenden, E. S. *Summary and Interpretation: National Survey of the Education of Teachers*, Vol. 6, U. S. Office of Education. Government Printing Office, Washington, 1932.

Broad Versus Specialized Knowledge

A second area in teacher training deals with an area of specialization of knowledge with what he needs to know about the subject which he is going to teach. Before looking at this area, it is necessary to understand clearly what American schools are for. According to President Henry Hill of George Peabody College for Teachers:

> The purpose of the American high school, in the words of an Englishman who sees this more clearly than most of our college professors, is to provide such training and education and practice as seem necessary for the induction of all young men and women in the mores of the society in which they will move. To think that the chief purpose of the American high school is to produce scholarship is to make the whole matter ridiculous, and seriously interferes with getting on with the really fundamental, abiding, difficult problems before us.[3]

And again, from the report of the American Association for the Advancement of Science, we find the following statement:

> The majority of students in high school need the kind of science courses which fit their present interests and their future needs as citizens. Such courses must be well taught to be successful with thorough treatment of topics taken up and with application to consumer problems, personal and public health, the use and conservation of natural resources, international relations and so on.[4]

This report goes on to state further that many colleges have adopted standards of concentration in the major department which make it difficult and often impossible for undergraduates to secure good preparation for teaching in as many as three sciences. While present standards may be appropriate for the future research scientist, they are not good for the future high school teacher. Colleges should provide opportunity for a concentration which shall not lie in one department but which shall spread not too thinly over at least three subjects in the sciences and mathematics.

These comments of the American Academy of Science are true of the preparation of teachers in almost every area. The typical curriculum of a large university or liberal arts college is directed toward the training of specialists and not toward the training of high school teachers. The course offerings which are presented point toward the preparation of individuals who know more and more about less and less. They do not include the broad general problems of a whole field. They may be necessary to produce persons capable of scholarly research and the advancement of knowledge, but there should be some way to select these individuals, and to educate them separately. As Henry Hill has said:

> Our attempt 'to educate everybody' is unique in world history. It is perhaps more an education involving attitudes, and emotions and skills than scholarship and intellect. I have always seriously doubted whether as many as five per cent of the earth's inhabitants had either the capabilities or the interest to become scholars.[5]

It is about time that institutions of higher education recognized this hard fact of life and set up an educational program which would enable scholars to move ahead and, at the same time, enable those who are not scholars to receive the broad, rich education within any subject matter field which will make them

[3] Hill, Henry H. "The Teacher Must Learn His Craft." *The Peabody Reflective*, March, 1949, p. 83.

[4] American Association for the Advancement of Science, Cooperative Committee on Science Teaching, mimeo., 1946, p. 109.

[5] Hill, Henry H. "The Teacher Must Learn His Craft." *The Peabody Reflective*, March, 1949, p. 83.

far better citizens and far better teachers than any of us.

What the prospective teacher needs is broad knowledge in a subject matter field rather than highly specialized knowledge. He needs to be trained within any area so that he understands its broad scope and its interrelationships. Only this training will enable him to acquaint students with its scope and relationships.

Social Culture

The third area in which a teacher must be trained is in that of understanding the nature of society. Much of what has been mentioned earlier under general education fits in here, and I will not dwell upon it further, but merely repeat that it is an area which needs attention.

Human Nature

The fourth area is that of training in the nature of man. It is here that anthropology, sociology, and most particularly psychology should make great contributions. The teacher must have a thorough grounding in the nature of human nature, in the human sciences, so that he will understand how man ticks, what makes him tick, and how to make him tick in different ways.

Professional Methods

A fifth area of education is related to the manipulation of the environment by the teacher. It is the field of professional methods of teaching. These should come late in the education of the teacher, but they should arise out of constant and continuous observation of schools in action, out of the study of the nature of human nature, and out of the nature of society. It is frequently assumed that methods are related to what is taught rather than whom is taught. Colleges and universities multiply methods courses incredibly. There are methods of teaching arithmetic, methods of teaching algebra, methods of teaching mathematics, methods of teaching biology, methods of teaching chemistry, methods of teaching French, methods of teaching Latin, and so on and on, down through the long list of subjects that are offered in the typical American high school. Nowhere do I know of a course in methods of teaching students, yet they, and they alone, are taught.

Methods of teaching, while they may be accepted verbally, become effective only as they are practiced. There must be long and continued opportunities for prospective teachers to do this under the observation of master teachers who can give them criticism, advice, and assistance.

An intensely practical reason for modifying teacher training programs in these ways stems from the very vigorous activities of the Illinois Secondary School Curriculum Program. If I am any judge of what is happening, the schools are developing programs which will call for teachers who must, if they are to be successful, possess training of the type described.

Summary

In summary, the training of teachers is a complex and difficult task. If it is to be effective, it must produce an individual whose knowledge is integrated toward helping students to learn. It must produce persons who are aware of the need for

change, and who seek to develop this awarness in others. To do this, it makes use of broad general education in order that teachers may have desirable personalities. It includes subject area courses which are directed toward an understanding of people and relationships. It includes thorough grounding in the human sciences. It includes long practice in using methods of teaching students.

I have attempted to indicate what, in my judgment, might be a better program for training teachers for tomorrow's schools. One of the more intangible, but most important, attributes of the superior teacher has been left until the last for purposes of emphasis—the terribly urgent need for a better citizenry which comes from the great social problems of tomorrow. When these problems are enhanced in complexity and danger by atomic energy, they cannot be met by skill and competence alone. A deep and abiding sense of the importance of teaching must be left within the heart and mind and spirit of each graduate. There must, of course, be love for children, affection and respect for fellow teachers, a desire to secure increasingly greater competence and belief in the essential human values of democracy.

These are important, but of themselves they are not enough. They must be coupled with a fierce determination, a kind of missionary zeal to make the world a better and a safer place for man because of what is done in school. Developing this spirit is the great task of every institution which is training teachers. In it, we cannot and we will not fail.

PROGRAM FOR THE 42nd ANNUAL MEETING
PAPERS PRESENTED

ARCHAEOLOGY AND ANTHROPOLOGY

C. C. BURFORD, *Chairman*
Urbana

*1. More Data on the Hopewell in the Peoria Region: Ethel Schoenbeck, Peoria.
2. Folsom Points in Illinois: William Smail, Loogootee.
3. You Can Still Find Them: Dr. Dan Morse, Peoria.
4. News and Comments—The Contemporary Archaeological Picture: Claude U. Stone, Peoria.
5. The New Building, Illinois State Museum: Thorne Deuel, Springfield.
6. Sauk and Fox Indian Ceremonials, Black Hawk State Park, Rock Island, Illinois: John H. Hauberg and Russell P. Neuwerk, Rock Island and Moline.
7. Ceramic Series in the Illinois River Area: John C. McGregor, University of Illinois, Urbana.
*8. The Non-Mississippi Manifestations at the Fisher Site: Charles E. Gillette, University of Chicago, Chicago.
9. Results of Two Seasons of Archaeological Work in the Starved Rock Area: Graduate Students, Department of Anthropology, University of Chicago, Chicago.
   A. Introduction: Kenneth G. Orr.
   B. A Non-Pottery Manifestation: William Mayer-Oakes.
   C. The Earlier Woodland Manifestations: Elaine Bluhm.
   D. Possible Interrelations of the Heally and Fisher Manifestations: Molly Allee.
   E. The Fort Ancient Manifestations: Gordon Keller.
   F. Problems of the European Occupation: Richard S. Hagan.
   G. Significance of the Cultural Stratigraphy: Kenneth G. Orr.
10. Pictures of Archaeological, Historical, and Scenic Locales in Southern Illinois: Irvin Peithman, Carbondale.

BOTANY

R. M. MYERS, *Chairman*
Western Illinois State College, Macomb

*1. Initial Report on the Vascular Plants of Southern Illinois: Wm. M. Bailey, Southern Illinois University, Carbondale.
2. Sanctuaries: Jens Jensen, The Clearing, Ellison Bay, Wisconsin.
*3. The Ferns of the Rock River Valley in Illinois: E. W. Fell and George B. Fell. Junior author, U. S. Soil Conservation Service, Rockford.
*4. A Checklist of the Vascular Plants of Winnebago County: George D. Fuller, E. W. Fell. and George B. Fell. Senior author, Illinois State Museum and University of Chicago,
5. Antibiotic Studies with Verticillium albo-atrum: L. R. Tehon and J. C. Carter, Illinois State Natural History Survey, Urbana.
*6. Embryo Development of the Pond Cypress (Taxodium ascendens Brongn.): Margaret Kaeiser, Southern Illinois University, Carbondale.
7. The Ralph Emerson Preserve, Rockford, Illinois—an Outdoor Botanical Laboratory for Rockford College: Evelyn I. Fernald, Rockford College, Rockford.
8. Intra-inbred Selections in Maize: O. J. Eigsti, Northwestern University, Evanston.

* Published in this volume.

CHEMISTRY

W. P. CORTELYOU, *Chariman*
Roosevelt College, Chicago

1. Decomposition Potentials to Identify Sugars: G. W. Thiessen and Vada Treloar Tschaepe, Monmouth College, Monmouth.
2. The Periodic Chart and the Total Number of Elements: Frank O. Green and Bernard S. Jackson, Wheaton College, Wheaton.
3. Report on the New National Cooperative Undergraduate Chemical Research Program: E. H. Cortelyou, Illinois Institute of Technology, Chicago.
4. Factors Influencing Undergraduates Research: Ward V. Evans, Frank P. Cassaretto, and Theodore G. Klose, Loyola University, Chicago.
*5. The Place of Science in General Education: Sister Mary Marguerite Christine, BVM, Mundelein College, Chicago.
6. Seminar—The Future of the Chemistry Section of the Illinois Academy of Science: Panel Discussion. Speakers to be announced.

GEOGRAPHY

JOHN F. LOUNSBURY, *Chairman*
Northwestern University, Evanston

1. The Panama Canal Scheduled for a Major Operation: W. O. Blanchard, University of Illinois, Urbana.
2. Geographic Aspects of the New Political Structure of India: Alfred W. Booth, University of Illinois, Urbana.
3. The German Potash Industry and its Recent Development: Vernon Brockman, Northwestern University, Evanston.
4. A preliminary Investigation of the Population Cluster in the Lake St. John-Saguenay Valley: Voris V. King, Illinois State Normal University, Normal.
5. Developments in Finland's Economy Brought About by World War II: Lauri J. Niemuela, Northwestern University, Evanston.
6. Polar Eskimos of Greenland and Their Environment: William E. Powers, Northwestern University, Evanston.
7. The Russian Doukhabors in West Kootenay, British Columbia: Malcolm E. Robinson, Northwestern University, Evanston.
*8. The Pulp and Paper Industry in the Lake States—A Study in Industrial Location: L. Majorie Smith, Northwestern University, Evanston.
9. Transportation into the Fountain Square Shopping Center of Evanston, Illinois: Jack A. Bradley, Evanston Community College, Evanston.
10. The Illinois Coal Market: Willis L. Busch, Illinois State Geological Survey, Urbana.
*11. Occupance of the Southern District of Southern Illinois: John H. Garland, University of Illinois, Urbana.
12. The Calumet Area Industrial Terminal: Nina T. Hamrick, Illinois State Geological Survey, Urbana.
13. The Climatic Regions of Illinois: John L. Page, University of Illinois, Urbana.
14. Relationships of Southern Illinois Orchards to Physical Factors: Dalias A. Price, Southern Illinois University, Carbondale.
15. Farm Management and Conservation in DeKalb County, Illinois: Martin W. Reinemann, Northern Illinois State College, DeKalb.

GEOLOGY

PERCIVAL ROBERTSON, *Chairman*
Principa College, Elsah

*1. The Present State of Knowledge Regarding the Pre-Cambrian Crystallines of Illinois: Robert M. Grogan, Illinois State Geological Survey, Urbana.

* Published in this volume.

*2. Facies Analyses of Niagaran Rocks in Illinois: H. A. Lowenstam, University of Chicago, Chicago.
3. The Late Cenozoic History of Southern Illinois: Morris M. Leighton and Harold B. Willman, Illinois State Geological Survey, Urbana.
*4. Physical Characteristics of the Oolite Grains of the Ste. Genevieve Formation: Raymond S. Shrode, Illinois State Geological Survey, Urbana.
5. Scenic Geology of Southern Illinois Ozarks: L. O. Trigg, Eldorado.
*6. Factors Affecting Laboratory Measurement of Permeability of Unconsolidated Glacial Material: Robert D. Knodle, Illinois State Geological Survey, Urbana.
7. Geological and Geophysical Studies of the Glacial Groundwater Aquifers in the Champaign-Urbana Area: Merlyn B. Buhle and John W. Foster, Illinois State Geological Survey, Urbana.
8. The Warsaw Formation in the Subsurface of Western Illinois: Donald B. Saxby, Illinois State Geological Survey, Urbana.
9. The Neda Iron Ore in Northeastern Illinois: L. E. Workman, Illinois State Geological Survey, Urbana.

PHYSICS

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*6. A Simple Circuit for Measuring Variations in Electrical Resistance of a Human Being Under Emotional Stress: A. F. Silkett and Mae A. Driscoll, University of Illinois, Navy Pier, Chicago.
7. Physics Applied to Watchmaking: C. N. Challacombe, Elgin National Watch Company, Elgin.
*8. Electronic Aids to Control and Measurement: Howard C. Roberts and Richard E. Wendt, Jr., University of Illinois, Urbana.
9. Quantitative Experiments on Normal and Oblique Precession: Philip A. Constantinidies, Wilson Branch Chicago City Junior College, Chicago.
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11. Some Factors in Determining a Student's Grade in a Science Course: Paul E. Martin, Wheaton College, Wheaton.
12. A Semantic Approach to the Elementary Laboratory: Andrew Longacre, University of Illinois, Urbana.

PSYCHOLOGY AND EDUCATION

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Theme: Developmental Projects in Science Education in Illinois Schools.
1. The Role of Science in the Common Learnings Program: Louise Riddle, Oakwood Township High School.
2. What we are doing in Biological Science: Charlotte Grant, Oak Park Township High School, and F. G. Weber, West Senior High School, Rockford.
3. What we are doing in Physical Sciences: Ralph Edwards, Streator Township High School, Streator, and Robert F. Seamon, University High School, Urbana.

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4. Panel Discussion: The Implications for Teacher Training.
R. Will Burnett, Professor of Education, University of Illinois, Urbana.
Bjarne Ullsvik, Professor of Mathematics, Illinois State Normal University, Normal.
John D. Mees, Principal and Instructor in Biology, University High School, Southern Illinois University, Carbondale.
L. Wallace Miller, Professor of Biological Science, Illinois State Normal University, Normal.
T. A. Nelson, Instructor in Chemistry, Lyons Township High School and Junior College, LaGrange.
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SOCIAL SCIENCE

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1. An Integrated Approach to Industrial Problems: Donald E. Wray, University of Illinois, Urbana.
2. Problem of the Sociology of Knowledge: Godfrey Delatour, Visiting Professor from Columbia University at the University at Illinois, Urbana.
3. Rationalism, Empiricism, and Sociology: Robert Bierstedt, University of Illinois, Urbana.
4. Some Problems of Methodology in Anthropology: Oscar Lewis, University of Illinois, Urbana.
5. An Evaluative Study of the Group Work Process in an Interstitial Urban Area (Chicago's West Side): LeRoy L. Kohler, Bradley University, Peoria.
*6. The Structure and Institutionalization of a Protest Group: F. E. Houser, Wheaton College, Wheaton.
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*8. Southern Illinois, A Cultural Area: William J. Tudor, Southern Illinois University, Carbondale.

ZOOLOGY

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1. Problems of the Small Animal Colony: Bertrand A. Wright, The Armour Laboratories, Chicago.
2. Robert Kennicott and the Chicago Area Herpetofauna: Albert G. Smith, Loyola University, Chicago.
*3. A Survey of the Unionidae of the Upper Reaches of the Mackinaw River: Garwood A. Braun, University of Illinois, Urbana.
*4. Genetic Variation in Populations of Drosophila melanogaster in the Chicago Area: Sidney Mittler, Illinois Institute of Technology, Chicago.
5. Data on the Sex-biology of Two Arionid Slugs: Glenn R. Webb, University of Illinois, Urbana.
*6. Parasites of the Ranidae (Amphibia) XIV: A. C. Walton, Knox College, Galesburg.
7. Arthropods of Medical Interest Collected in the Mediterranean Area (An Annotated List): Garland T. Riegel, Eastern Illinois State College, Charleston.
8. Effects of Orchidectomy in Golden Hamsters: Willis E. McCray and Charles L. Foote, Southern Illinois University, Carbondale.
9. Some Instances of Diapause among Insects: W. V. Balduf, University of Illinois, Urbana.
*10. Notes on the Biology of a Common Gastrotricha of the Chicago Area, Lepidoderma squmatum (Dujardin): Robert J. Goldberg, Chicago City Junior College, Chicago.
11. A Quantitative Study of the Relation between the Resting and Acting Potential of the Frog Eye: Stewart W. Freyburger, University of Illinois, Urbana.
*12. Incidence of Trypanosoma Infection in Small Rodents of Champaign County, Illinois: Russell E. Nelson, University of Illinois, Urbana.

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A—BIOLOGICAL AND SOCIAL SCIENCES

1. Most Common Rotifera of Lake Michigan Collected in the Chicago Area: Wilma Lehman and Frances Fazio, Mundelein College, Chicago.
2. Experiments in Embryonic Development of a Chick: Willye Thomas, College of St. Francis, Joliet.
3. A Technique for Anaerobic Methods: Joseph Gray, Northwestern University, Evanston.
4. Variation of the Quantity of Nucleic Acid in the Tissues of Drosophila at Different Ages: Mary Russel, Mundelein College, Chicago.
5. The Anatomy of Molgula: Joseph Fisher, Loyola University, Chicago.
6. Variations of the Quantity of Nucleic Acid in the Tissues of Oxalis at Different Ages: Virginia Dineen, Mundelein College, Chicago.
7. Asthma Brought Up to Date: Margeurite Bonner, College of St. Francis, Joliet.
8. Nuclear Apparatus of Various Oxytrichidae (Ciliata, Hypotricha) at Different Stages of Their Life Cycle: Mary Joan Kornetzke and Marilyn Tucker, Mundelein College, Chicago.

*9. Improved Methods of Activating Tapeworm Embryos: Shirley Nice, Monmouth College, Monmouth.

10. Simplified Photomicrography with the Hand Camera: Frank Fitch, Monmouth College, Monmouth.
11. Embedding Biological Specimens in Plastics: Janet Boles, Monmouth College, Monmouth.
12. Hemoglobin Percentages in College Students in the Spring Compared with Early Fall Readings: Jane Martin, Monmouth College, Monmouth.

B—PHYSICAL AND EARTH SCIENCES, AND MATHEMATICS

1. The Glacial Geology of Otter Creek Area, Jersey County, Illinois: E. Gene Smith, Principia College, Elsah.
2. Medical Application of Radioactivity: Anne Bannon, College of St. Francis, Joliet.
3. Results of a project for the Volumetric Determination of Bismuth: Bruce Kirkman, Southern Illinois University, Carbondale.
4. A Study of the Porphyrin-like Substances in Fresh Horse-Radish: Rosemary Legenza and Vivian Walkosz, Mundelein College, Chicago.
5. Codeposition of Zinc and Iron: Douglas S. Fairgrieve, Principia College, Elsah.
6. Titration of Periodates: William Ulrich, Southern Illinois University, Carbondale.
7. Isolation of Certain Compounds from Green Leafy Vegetables by Chromatographic Methods: Paper presented by Mary Lou Killey, College of St. Francis, Joliet. (Research by the speaker and Jane Dilger, Mary Virginia Morse, Lorraine Sporar, and Shirley Vescovi, College of St. Francis, Joliet.)

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ARCHAEOLOGY AND ANTHROPOLOGY

LATE WOODLAND OCCUPATIONS OF THE FISHER SITE, WILL COUNTY, ILLINOIS

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The Fisher Site is situated on the south bank of the Des Plaines River about a mile upstream from where it joins the Kankakee to form the Illinois River. The site originally consisted of twelve burial mounds and a series of probable house pits. Throughout the site there occur burials which show no cultural affiliations, and therefore are not considered in the study.

In 1906 George Langford began his diggings at this site and found it to be of sufficient importance to be of interest to midwestern archaeologists. His work on the site continued intermittently until 1929. He subsequently gave his materials and notes to the University of Chicago, where they have formed the basis of further research and study of the Fisher Site.

In the two larger mounds Langford found definite evidences of stratigraphy. Each mound was divided into three levels, the upper, the middle, and the lower. The upper and middle levels were each separated from the one beneath by a dark seam, which he interpreted to be old ground surfaces. The depth of burial was not significant, but the relative age could be determined by tracing the burial fill to one of the three levels, and determining if either or both of the black seams had been pierced.

In the lower level Langford found burials without artifacts. He subdivided this level into two parts, on the basis of burial type and fill. Some were carefully flexed burials lying on the left side with grave fill indistinguishable from the surrounding gravel. This fact led him to call them "concealed burials." The other burials in the lower level were "sprawling" in position, lacking orientation or any semblance of planned arrangement. In these the grave fill was very slightly discolored by black soil, and he called them "semi-concealed." In all cases where the "concealed" and the "semi-concealed" burials were found in close association with each other, the former were always beneath.

In the middle level Langford found extended burials with grave goods. Although much of the material is very similiar, he was able to separate them into two groups on the basis of pottery differences. One group is marked by a decorated shell-tempered pottery, whereas the other group is marked by a less elaborate grit-tempered pottery decorated with many of the same motifs found on the shell-tempered ware.

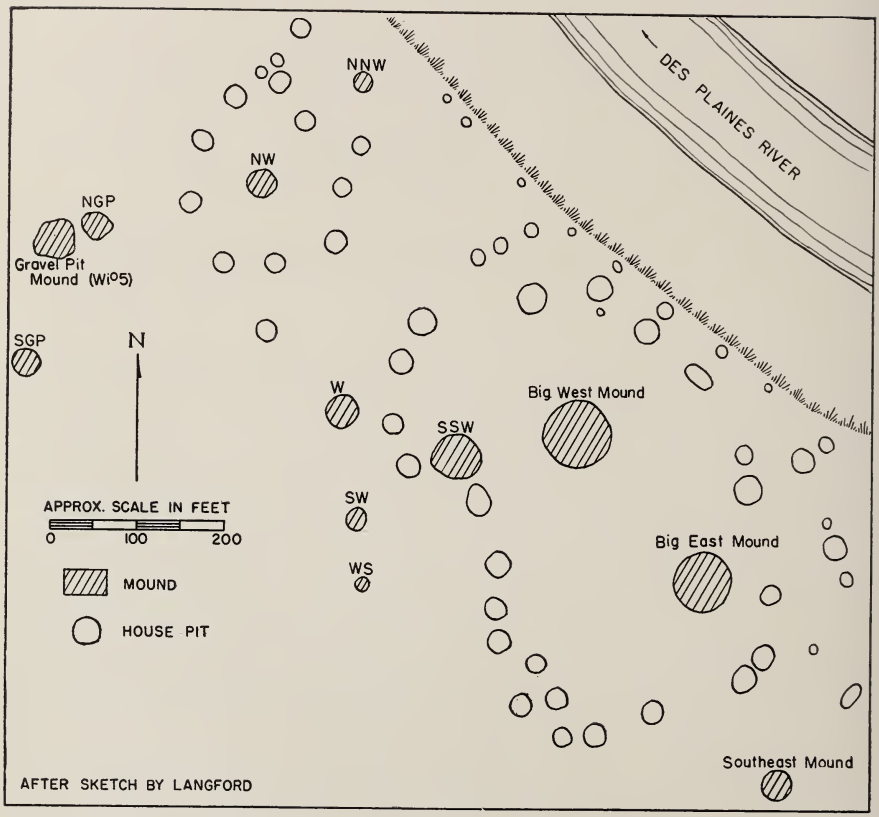

Fig. I.—Relative locations of features of the Fisher Site.

The problems of the upper level are based, for the most part, on the inability of the excavators to ascertain the stratigraphy within this level. The burials are found in many positions, some with and some without artifacts. Langford distinguishes three different cultural horizons within this level. One is marked by a grit-tempered unornamented pottery, quite similar to the grit-tempered ware of the middle level. The second is a Late Woodland horizon marked by stray sherds and stemmed projectile points that are apparently present in the fill, rather than associated with the burials. The third is an Historic horizon which has no pottery, and is marked by trade materials of European origin, and in some cases, flint projectile points and shell beads of Indian manufacture.

Langford arbitrarily typed the materials from all of the other mounds and the pits on the Fisher Site, using as his pattern the stratigraphy and typology which he found in the two big mounds, as described above. His Gravel Pit Mounds, where he found a concentration of what he called Late Woodland, and his Southeast Mound where he found a concentration of the Historic, were dated as the last occupations of the

site, since they showed similarities to two horizons of the upper level of the large mounds.

In 1946 John W. Griffin studied Langford's material and notes and selected for consideration two types of pottery, one with shell temper and one with grit temper, both with clearly defined Upper Mississippi affiliations. These he subjected to further intensive study and found that they fell into three periods. *Period A* included the decorated shell-tempered ware, *Period B* included the decorated grit-tempered ware, and *Period C* included the undecorated grit-tempered ware. He considered this to be their chronological sequence, which was also Langford's conclusion on the Upper Mississippi material. The complete findings of Griffin's study are found in his master's thesis, University of Chicago, 1946.

In 1940 a joint expedition of the Illinois State Museum, the University of Chicago, and the W.P.A. entered the field under the direction of Gretchen Cutter Sharp. This expedition was particularly interested in the relationships of Late Woodland and Historic materials to the other manifestations on the site. So far the results have been published in only one article (Deuel, 1940). The present paper is concerned with a more intensive study of the same problem.

The Late Woodland manifestation on the Fisher Site is identified with pottery having the following characteristics: Grit temper, cord marking, reddish paste, jar form with rounded bottom, and ranging from low to hard firing. It occurs with and without a collar, with and without castellations, with and without a definite shoulder, and with and without notched lips. Lip notching was done with either plain or cord wrapped stick. Most examples have round mouths, but some occur with angular openings. The thickness ranges from 3.2 mm to 8.3 mm. No lugs, handles, or other appendages have been found. Decoration seems to be limited to punctates in parallel lines between the neck and shoulder. Langford reports two examples of parallel single cord impressions, but these sherds are not available for study.

In the current study, the sherds found in the Gravel Pit Mound Wi°5 were analyzed and the Late Woodland pottery arbitrarily divided into six classes.

Class I

One reconstructed pot and several sherds are characterized by low firing, angular mouth, flaring rim (slightly thickened below the lip to give the effect of a collar), the general lack of a defined shoulder, and a relatively small size.

Class II

One reconstructed pot and several sherds have vertical rims, thickened below the lip to form a collar. This thickening is apparently due to a folding of the rim. It has a clearly defined shoulder and a characteristic change in direction of paddling at the shoulder. Above the shoulder the paddling is vertical, and below it it is diagonal. These pots are generally larger in size than Class I.

Class III

The sherds in this group indicate pots small in size, with thin walls,

and without collars. There is considerable variety in all other characteristics.

Class IV

One large sherd is separated into this group by its similarity to Tampico pottery in its rim and shoulder form, and it is smaller in size than Class I and Class II.

Classes V and VI

These two classes show variations in decorative treatment. Class V sherds have parallel lines of punctates on the shoulder, while Class VI sherds have horizontal lines of single cord impressions.

There were 415 Woodland sherds found in Wi°5. Because of the great homogeniety of the Woodland body sherds, and their close resemblance to the body sherds of the Langford Corded (*Period B*), this classification is based upon the variations found in the rim and shoulder treatment of 73 rimsherds, 51 from Wi°5, and 22 from the Village Area. These six classes constitute the pottery of the Des Plaines Complex, which is a variant of the Tampico Phase.

There are two evidences on the site that this Late Woodland pottery may be present at an earlier time than has heretofore been suspected. Langford indicated in a cross section that the upper level of the larger mounds was a grey-brown earth, but that the middle level was a brown earth. The stratigraphy of Wi°5 is apparently similar to that of the two larger mounds—upper and middle levels divided by a black seam. Examples of the Late Woodland pottery have been found definitely beneath the black seam in Wi°5, in a brown earth stratum. In a test trench pit, both types of soil were present, but the Woodland sherds were in the brown earth which lay at the bottom of the pit. This would seem to indicate contemporaneous existence with Langford's middle level, based on the similarity of the soil.

Another indication of a probable earlier time level for this Late Woodland pottery is burial East Mound 21 This burial is in the big East Mound, and had associated with it a pot similar to those of Class III. Langford describes this burial as follows: "This excavation gave a fine wall section showing the black seam undisturbed three feet below the mound surface. One and one-half feet below that was a thin dark seam over a five inch ash and dirt layer, and then another seam. The grave had been dug through the ash layer and the lower seam, but the upper seam was intact." This places it definitely in the middle, or brown earth stratum of the big East Mound, and indicates the coexistence of this Late Woodland type pottery with John Griffin's *Period A* pottery (shell-tempered Upper Mississippi) and his *Period B* pottery (decorated grit-tempered Upper Mississippi) because they all occur in the same soil stratum.

The major portion of the Late Woodland pottery found on the site is found in Wi°5. It seems to appear as mound fill, and is not associated with the burials in the mound. One pot, which has been reconstructed, was found scattered over an area fifteen feet by twenty feet, and above and below the black seam, where it had evidently been carried by intrusive digging. Other sherds are

similarly scattered over a wide area, both horizontally and vertically. Any reconstruction usually contained pieces from more than one square and level. The fact that sherds are found in the fill closely associated with undisturbed burials indicated that this pottery antedates the burials, and probably the mound itself.

Associated with the burials in this mound are artifacts, including bone harpoon points, and other bone and stone objects, whose cultural affiliation is at present unknown but they show similarities to Owasco.

Let us now consider the cultural affiliations, in the Illinois area, of the Late Woodland pottery at this site. Collared pottery with an angular mouth similar to Class I is found at the Corbin Site, at the Salt Well Site, at the Old Hotel Plaza Site, all in the Starved Rock area. Ethel Schoenbeck has reported a sherd similar to this type from the Clear Lake Site in Tazewell County (Schoenbeck, 1946, p. 389) and Barrett also reports them as present in the Azatlan material in Wisconsin (Barrett, 1933, pp. 319-20).

The pottery with the round mouth and vertical rim (Class III) is similar to that found in the Gooden Mound in Fulton County (Cole and Deuel, 1937, p. 116), at the Mills Village Site in Joe Daviess County (Bennett, 1945, plate 30), and in the Azatlan material from Wisconsin (Barrett, 1933, pp. 308-10). Similar materials found at the Boulder Site in Clinton County are classed by Elaine Bluhm as belonging to the Dillinger Focus (Bluhm, 1948).

In summary we may say that the Late Woodland manifestation at the Fisher Site seems to be a post-Hopewellian development. The Late Woodland of this particular type has to date been found only in the Illinois Area. It has definite relationships to both the Dillinger Focus and the Maples Mills Focus. The pottery shows a definite influence from the Monks Mound Aspect of the Middle Mississippi Phase. It has in turn influenced the Langford pottery, where its peculiar styles of grit tempering, cord marking, folded rim, and lip notching may be traced as survivals.

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MORE DATA ON HOPEWELL SITES IN PEORIA REGION

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This paper gives a preliminary list of objects found at the Rench Village site, north of Mossville, and gives a few comparisons with collections from the Clear Lake and Steuben village sites, all Hopewell sites of the general Peoria region. It also reports several unrecorded items from Clear Lake and Steuben sites. Collections were made by Anson M. Simpson, and by Mr. and Mrs. George Schoenbeck, members of the Peoria Academy of Science.

Rench Village Site

Rench Village, listed as site No. 3 in the Peoria Academy survey, is about four miles north of Mossville, Peoria County, in Medina Township, sec. 15, T. 10 N., R. 8 E. It consists of about 20 acres of flat bottomland at the base of the bluff and north of Dickison Run, a small creek. It is part of the farm owned by Mrs. Bertha Purcell of Mossville, occupied by Floyd Rench, and present use includes plowed fields, a vegetable garden, and a chicken yard. Indian mounds are located on the Sturm property on the bluff north of the Rench Village site. The Dickison Mounds are about two miles to the east and the Mossville Village site is about three miles to the south.

The village and mounds were visited by Fay-Cooper Cole and a group from the University of Chicago in 1941. Survey sheets are in the files of the University of Chicago and the Illinois State Museum at Springfield. A brief report on the site, by A. M. Simpson, was given at the 1944 meeting of the Illinois Academy of Science at DeKalb, Illinois.

It has been reported that the owner made an early collection of material from the Rench Village site which he sold to a Peoria dealer. Simpson made his first collection in 1937. The Schoenbecks joined in surface collecting the same year, and several years later undertook a limited amount of excavating. About fifty trips have been made, the last of which was on May 1, 1949. Other collectors from the Peoria Academy of Science include Leroy Elliott, Virginius Chase, Bob Poehls, Almon Buis, Dr. Dan Morse, and D. Morse, Jr.

Excavations have covered an area of perhaps 120 square feet to a depth of about 5 feet—a limited area in comparison to excavations at Clear Lake. The upper depth was mostly bare of material, but several burials were found, and scattered among the village debris were human bones, including skulls and jaws. One skull was found by itself; there was one partial skeleton of a human embryo. At another location one adult burial occurred at a depth of only 18 inches, with village material all around. A thin rough slab of stone, four to five inches in diameter, lay beneath the skull.

Part of the skeletal material from Rench Village, together with material from Clear Lake and Sister Creek

Photograph by Barclay Photo Co.

RENCH VILLAGE SITE

First Row:
Rim of Bossed, Channeled, "Brushed" pottery.
Sherd of polished, thin, limestone-tempered Hopewell pottery with "brushed" marks in the zoned areas.
Rim of thin, polished Hopewell with "brushed" marks placed horizontally.
Rim of polished gray, incurved, similar to Marksville Plain.
Shell spoon, with hinge removed.
Shell hoe, perforated.

Second Row:
Types of points.

Third Row:
Pendant.
Pipe bowl, highly polished.
Stone artifact, with polished tip.
One-half of polished stone ball.
Copper bead or bangle.
One-half pendant, unfinished, with two perforations—one from each side but not meeting.
Grooved stone maul.
Stone with two inverted cone-shaped pits.

CLEAR CREEK AND STEUBEN SITES

Fourth Row:
Pipe from Clear Lake site.
Pottery artifact, sectioned into six sections by rows of punctates, from Clear Lake.
Chert ball, with many little planes on surface, Steuben Site.

Hopewell Mound, was given to Thorne Deuel, Director of the Illinois State Museum, for a study of Hopewellian remains.

Collections from the Rench Village site include pottery rims, body sherds, and pots; shell artifacts and refuse; stone items; chert artifacts and scraps; bone artifacts, refuse, and burials; copper bead or bangle; carbonized corn, corn cob, and acorn; charcoal and mica.

Pottery

All pottery is Woodland, Hopewellian, and cord-decorated, with the exception of one Mississippian rim and two sherds. Like the Steuben pottery, it is simpler than that from Clear Lake, lacking richness of variation in decoration. The fine Hopewell is poorly represented, and the cord-decorated is present in only small amounts. Cord-decorated and Mississippian sherds were collected only from the plowed surface; the other types were found both on the surface and in the excavations. Pottery fragments included 313 rims, hundreds of body sherds, and portions of nine pots, two of which have been projected.

Dentate stamped[1] is the dominant type, mostly of simple decoration. Punctate ware, dominant at Steuben, ranks second at Rench Village. Ware showing the cord-wrapped paddle-edge stamps, abundant at Clear Lake, is scarce here as at the Steuben site. The proportion of Woodland cord-roughened undecorated pottery is larger at Rench Village than at Clear Lake. The boss, found frequently at Clear Lake, is infrequent here as at Steuben site. The cord-decorated ware lacks certain distinguishing characteristics of the Clear Lake pottery and seems closer to that of the Knoche Village, an almost pure Maples Mills site.

The dentate-stamped pottery collected includes 106 upper rims and 50 lower rims. Most designs are the simple repeated stamp. The rocked dentate stamp and the snowshoe appear once each. Six rims are odds. The crescent stamp is found in three upper rims and one lower rim.

The punctated ware, consisting of 91 upper rims and two lower rims, has mostly the simple two and three punctates, applied unevenly on both cord-roughened and smoothed surfaces. Single punctates decorate the outer edge of the lip on 35 of the rims. Several rims are odds.

Woodland cord-roughened pottery, with the cord-roughening extending to the lip, is represented by 36 rims, all of which are undecorated except two that have bosses. Plain smooth rims, undecorated, number 33; two of them are sand-tempered, similar to a Clear Lake ware.

Bar-stamped pottery is represented by two upper rims that show a plain bar stamp on a smooth surface.

Incised pottery included 11 upper rims, six lower rims and other sherds. Three upper rims, two lower rims, and two body sherds are similar to Cole and Deuel's No. 1 type or Black Sands incised, in which the incising was over cord-roughening, with boss and punctates. Two upper rims and four lower rims were similar to Griffin's Morton incised type of ware. Six upper rims and 21 sherds are unclassified.

The cord-wrapped-stick stamp (Cole and Deuel's term) appears on only eight rims, three of thin ware and five of heavy ware. This stamp is such as could be made by the edge of a cord-wrapped-paddle and is termed by the writer the corded-paddle-edge stamp.

Some 28 body sherds show designs on alternate areas or in zones, such as are described for Cole and Deuel's No. 2 type pottery or Griffin's Havana zoned.

[1] Designated by Cole and Deuel, in "Rediscovering Illinois," as type No. 2, and by James B. Griffin, Curator of the Ceramic Repository, University of Michigan, as Naples Dentate-Stamped.

Representatives of the finer Hopewell pottery and imitations included 14 rims and 11 body sherds. Hopewell channeled rims show horizontal incising or "brushing" and rocked incising. Imitations are of Hopewell cross-hatched incised and the rocked stamp, such as can be made with the raw edge of a broken clam shell. One limestone-tempered polished thin body sherd has incised and "brushed" zoned areas. One rim is smooth, polished, and incurved, similar to Markville Plain.

Pot portions, sufficient to project the whole form, are mostly undecorated cord-roughened, both plain and punctate, but including two that are different. One is a ware not previously reported in Illinois, so far as the writer knows. The fragments show a channeled bossed rim bearing horizontal "brushed" markings and a body on which the same markings were applied vertically to a smooth surface. The marks are parallel grooves, long, straight, narrow, and shallow, such as might be made by a three- or four-tined fork with closely spaced sharp-cornered flat tines about 1/16 inch wide. The lip is rounded; diameter of mouth was 12 inches. The pottery is about ¼ inch thick and seems similar to Cole and Deuel's No. 2 or Woodland Plain ware in paste, tempering, etc. Two similar sherds were found at Clear Lake.

The second was a roughly made, seemingly barrel-shaped pot. It had two irregular rows of punctates on the rim and zigzag incisings on the body.

There were four cord-decorated rims, all with decoration on the inner side of the lip but only one with it on the outer rim. Tempering material includes a little of the black sharp-angled hornblende; most is other grit. One rim bears the ear or node but not on a raised point.

The Mississippian ware comprises one rim and two sherds. The rim is red-painted, smooth, curved such as that of a low bowl, and has a hole in it, made when the bowl was made and painted red, an unusual feature. One sherd is smooth and rather thick, the thinner sherd has been leached of its tempering.

The Rench Village pottery complex, as known to date, seems closer to that of the Steuben site than to the Clear Lake. Factors considered are the simplicity of the dentate stamp design with its lack of variation or elaboration; the importance of the punctate ware; and the scarcity of the corded-paddle-edge decoration and of the boss.

Shell Items

Shell items include a number of large clam shell hoes, shell spoons, clam shells packed with soil containing many fish scales, many refuse clam shells, and a large number of snail shells.

The hoes have a ¾-inch round hole in the center, and a portion of the hinge has been smoothed off at the top. Bottoms are often worn down. These have been found at Clear Lake, Steuben, and the Sister Creek Whitnah Hopewellian village also, as well as at Mississippian villages. Spoons were made from another species of shell, thin and smooth. Hinges were removed or smoothed down, and the dark surface on the back was partially removed. One spoon has a finely scalloped edge.

The clam shells packed with soil and fish scales are thought to have been used to scrape scales from fish. Similar ones were also found at Clear Lake. The refuse clam shells were found all over the village. Snail shells, all of the same species, were found in lots of 20 to 50 at a number of places in the excavations.

Copper

The only copper found was a cone-shaped bead or bangle of rolled sheet copper. A string of copper and shell beads was reported found about 1922 on the Charles Gauwitz farm across the road, probably a part of the Rench Village site.

Stone Items

Pitted stones, showing shallow rough peckings in the center on one or both sides, are numerous. A few stones have cone-shaped holes with smooth walls. Holes are about ½ inch deep.

There were 30 celts, counting both whole and broken portions. Axes are represented by one blade, broken off at the groove. There are two grooved mauls, round or oval granite boulders encircled by grooves about an inch wide.

There are the usual ball-shaped pecking stones, which are found at almost all villages; but the gouge, flat on one side and convex on the other, is rather rare. Several sandstone sharpening stones were found, their straight grooves worn shallow or deep.

There was one whole pendant and eight portions. One unfinished pendant has two borings from opposite sides, in the usual way, but they do not meet; edges and surfaces are only partly smoothed. Clear Lake excavations have yielded fewer pendants than Rench Village, but the Steuben site is represented in the Schoenbeck collection by 16 portions.

A rare item is half of a polished stone ball, 1¼ inches in diameter. The broken surface is also somewhat polished, particularly on the higher areas, as though from handling or smoothing. Another unusual item is a small oblong stone, two inches long, one side of which is flat and the other ridged, and which has a flat polished tip. Its name and use are unknown. There were also several roughly shaped flat blades, ¼ inch thick, shaped around three edges and broken on the other. The only pipe found is half of a highly polished bowl.

Chert

Chert items included points, scrapers, flake knives, drills, and a bird effigy. Points are abundant, as they are at Steuben. Types of points include Woodland, Hopewell, Red Ocher, Maples Mills, and Mississippian. The smallest is ¾ inches long, the largest is 3⅛ inches, but the average is 1½ to 2 inches long. The bird effigy is of white chert and is similar to two found at the Steuben site (one by the Schoenbecks and one by Elliott). Drills are winged. There are three types of scrapers, and chert scraps are plentiful.

Bone

Bone items, aside from burials, include several broken beamers; a few awls, both single and double pointed; and a quantity of animal bones—deer, elk, beaver, dog, fish,

and turtle. There were portions of large and small antlers, some of which had been cut. Two antler tips had been shaped to a point.

Vegetables Remains

Carbonized corn kernels were excavated in two places; some of them had small remnants of cob attached. Charcoal and a carbonized acorn were also found.

Mica

Material excavated included a two-inch fragment of mica.

Unidentified

A fragment of material ¼ inch thick and about three by five inches in size, badly deteriorated, somewhat resembles old leather or hide. It has not been identified.

Clear Lake Site

An unusual item from Clear Lake Village is a pottery disk, 5/16 inch thick and 1 3/16 inch in diameter, which has a punctate design on each side. Lines of circular punctates mark one surface into six sections, as a pie is cut; a line of punctates outlines the circumference of the other face. The side wall is smooth but the two faces are rough.

Another recently collected item is an incomplete or broken disk pipe bowl, 2 3/16 inches in diameter with a ½-inch stem hole centered in the disk. This brings the total number of Clear Lake pipes to seven, which represent at least five types.

The "Brushed" ware that is reported in this paper for the Rench Village site is also here reported for the Clear Lake site. Several grit-tempered sherds were identified some years ago by Griffin, but have been overlooked in the list of types reported.

Sherds of small-sized buff-colored sand-tempered pottery with thinned and rounded lips are reported for the Clear Lake site. The surface is plain; decoration includes an irregular gashing or incising, a low horizontal "welting," and notches, but most of the sherds are undecorated.

Steuben Site

For the Steuben site there is reported a marble-like object, 11/16 inch in diameter, that appears to be of white chert. The surface consists of many small planes. It was found on the plowed surface.

BOTANY

INITIAL REPORT ON THE VASCULAR PLANTS OF SOUTHERN ILLINOIS

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The part of the state commonly designated as Southern Illinois consists of the eleven southernmost counties, namely Jackson, Williamson, Saline, Gallatin, Union, Johnson, Pope, Hardin, Alexander, Pulaski, and Massac. The area has 3,751 square miles. Two great rivers form its boundaries, the Ohio on the south and east, and the Mississippi on the west. The Ozark Hills extend east and west across the central part of the region. This name is applied because the range of hills was formed by the same general unlift that produced the Ozark Mountains in Missouri. The Ozark Hills were formed from an escarpment at the southern edge of the Pennsylvanian rocks. These hills and their slopes are very much dissected by erosion.

Immediately north of the Ozark Hills is the plain which is the oldest glaciated area in Illinois. South of the Ozark Hills is a low, flat plain, which is in the Mississippi embayment of the coastal plain of the Gulf of Mexico. Much of the vegetation of this plain is decidedly southern.

To the areas described above may be added the Mississippi River, Ohio River, and Wabash River borders.

The altitude of much of the plains north and south of the Ozark Hills is less than 400 feet above sea-level; that of the Ozark Hills is generally between 600 and 800 feet. The two highest points are William's Hill, in Pope County, with an altitude of 1065 feet, and Bald Knob, in Union County, with an altitude a little less than that of William's Hill.

The plain north of the Ozark Hills and the northern slopes of these hills are drained by two rivers, the Big Muddy River which flows southwestward into the Mississippi River and the Saline River which flows southeastward into the Ohio River. The plain south of the Ozark Hills and the southern slopes of the hills are also drained by two rivers, the Cache River and the Big Bay, both of which occupy an old channel of the Ohio River. The Cache River flows southwestward, and discharges its water into the Ohio a short distance above the junction of the latter with the Mississippi. The Big Bay flows southeastward into the Ohio.

The soils of the greater part of Southern Illinois are not of very good quality. The fine texture and impervious subsoil of the upland soils prevent good drainage and aeration. During the winters the soil is unfrozen much of the time. There is much erosion and leaching by the winter as well as the summer and spring rains. The rapid leaching has resulted in soil acidity and in deficiency of mineral nutrients for plants.

Climate is the greatest factor in the development of soils and of vegetation. Southern Illinois extends from 37 degrees to 38 degrees north latitude. The summers are hot, averaging about 80 degrees F. for July. The temperature for January averages near the freezing point. The growing season has an average length of 190 days in the north part of the region to 210 days in the south part. The average annual rainfall of Southern Illinois ranges from 35 inches to 50 inches in different parts of the area. The highest rainfall of 45 to 50 inches occurs on the south slopes of the Ozark Hills. This higher rainfall is probably caused by the cooling of the warm, damp winds from the south as they ascend these slopes. The vegetation in this area is more mesic than in other parts of the region.

The heaviest rainfall is usually in the spring and early summer. In the later part of the summer the low pressure areas are sometimes so far north that the hot, dry subtropical winds blow across the region.

The principal type of vegetation in Southern Illinois consists of the hardwood forests. On the hills and uplands the oaks and hickories are the dominant species, associated with elms, maples, ash, sycamore, wild black cherry, and other species. On the flood-plains of the streams are found mixed hardwood forests.

Clearing the land for agricultural purposes, cutting the timber for commercial and domestic uses, and destructive fires have resulted in the destruction of most of the virgin timber. The Shawnee National Forest in Southern Illinois has been established by the purchase of forest land and submarginal land by the United States Government, in order to protect the forests from destruction and preserve them for future use, to protect the land with steep slopes from destructive erosion, and to alleviate destructive floods. Already the forestry station at Jonesboro is more than paying expenses by the sale of timber.

Only isolated, comparatively small areas of prairie vegetation occurred in Southern Illinois. A few small remnants of this prairie vegetation may still be found.

In Southern Illinois there are numerous species of plants that are limited to the southern part of the state, so far as Illinois is concerned. Among these are the following: the Short-leaf Yellow Pine *(Pinus echinata)*, on the bluffs just east of Wolf Lake, in the northwest part of Union County; the Pink Azalea *(Rhododendron roseum)* in the same locality; the Winged Elm *(Ulmus alata)*, the Cucumber Tree *(Magnolia acuminata)*, the Tulip Tree *(Liriodendron tulipifera)*, the Chestnut Oak *(Quercus montana)* on the higher elevations of some of the hills of Atwood Ridge, in Union County; the Bald Cypress *(Taxodium distichum)*, Water Elm *(Planera aquatica)*, Tupelo Gum *(Nyssa aquatica)*, Water Locust *(Gleditsia aquatica)*, and Virginia Willow *(Itea virginica)*, in the swamps and low woods of the plain south of the Ozark Hills; the Willow Oak *(Quercus phellos)* in Massac County; the Overcup Oak *(Quercus lyrata)*, in the south third of Illinois, in swamps and bottomland woods; Schneck's Oak *(Quercus shumardii)*, in damp woods near streams; Mississippi Hackberry *(Celtis laevigata)*, in the southern third of Illinois, on bottom lands of

large rivers; *Catalpa speciosa,* on bottom lands of the Ohio and Wabash Rivers; Sweet Gum Tree *(Liquidambar styraciflua),* in swampy woods; Red Buckeye *(Aesculus discolor),* in Union County State Forest and the Forest at Horseshoe Lake, in Alexander County; Farkleberry *(Vaccinium arboreum),* Southern Buckthorn *(Bumelia lycioides),* Mistletoe *(Phoradendron flavescens),* parasitic on elms and other bottomland trees; Gray Polypody *(Polypodium polypodioides),* a fern growing on rocks and trees in Jackson County and southward; Filmy Fern *(Trichomanes boschianum),* found in Jackson Hollow, Pope County; *Sedum pulchellum,* on sandstone rocks; Southern Cane *(Arundinaria gigantea),* on stream banks and in swamp places; wisteria *(Wisteria macrostachya),* and cross-vine *(Bignonia capreolata),* near the Ohio River.

In our explorations for vascular plants in Southern Illinois, we have collected more than 600 species. We are planning to continue this work.

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List of Species Collected

Equisetaceae
- Equisetum arvense L.

Ophioglossaceae
- Botrychium virginianum (L.) Sw.

Polypodiaceae
- Adiantum pedatum L.
- Asplenium platyneuron (L.) Oakes
- Asplenium trichomanes L.
- Athyrium angustum (Willd.) Presl.
- Camptosorus rhizophyllus (L.) Link
- Cheilanthes lanosa (Michx.) D.C. Eaton
- Cystopteris fragilis (L.) Bernh.
- Diplazium pycnocarpon (Spreng.) Broun
- Dryopteris marginalis (L.) Gray
- Onoclea sensibilis L.
- Pellaea atropurpurea (L.) Link
- Phegopteris hexagonoptera (Michx.) Fee
- Polypodium polypodioides (L.) Watt
- Polypodium virginianum L.
- Polystichum acrostichoides (Michx.) Schott.
- Pteridium latiusculum (Desv.) Hieron.
- Woodsia obtusa (Spreng.) Torr.

Pinaceae
- Pinus echinata Mill.

Taxodiaceae
- Taxodium distichum (L.) Rich.

Cupressaceae
- Juniperus virginiana L.

Typhaceae
- Typha angustifolia L.
- Typha latifolia L.

Sparganiaceae
- Sparganium eurycarpum Engelm.

Alismaceae
- Alisma subcordatum Raf.
- Echinodorus radicans (Nutt.) Engelm.
- Sagittaria graminea Michx.
- Sagittaria latifolia Willd.

Hydrocharitaceae
- Limnobium spongia (Bosc) Steud.

Gramineae
- Arundinaria gigantea (Walt.) Chapm.
- Bromus tectorium L.
- Poa pratensis L.
- Eragrostis pectinacea (Michx.) Nees
- Eragrostis poaeoides (L.) Beauv.
- Uniola latifolia Michx.
- Triodia flava (L.) Smyth.
- Elymus virginicus L.
- Hystrix patula Moench.
- Eleusine indica (L.) Gaertn.
- Digitaria sanguinalis (L.) Scop.
- Paspalum circulare Nash

Paspalum fluitans (Ell.) Kunth
Panicum anceps Michx.
Panicum polyanthes Schult.
Echinochloa crusgalli (L.) Beauv.
Setaria lutescens (Weigel) F. T. Hubb.
Cenchrus longispinus (Hack.) Fern.
Andropogon virginicus L.
Erianthus alopecuroides (L.) Ell.
Erianthus contortus Ell.
Sorghum halepense (L.) Pers.

Cyperaceae
Cyperus ovularis (Michx.) Torr.
Cyperus ferruginescens Boeckl.
Eleocharis obtusa (Willd.) Schult.
Scirpus lineatus Michx.
Carex vulpinoidea Michx.
Carex projecta Mack.
Carex grayii Carey
Carex frankii Kunth
Carex lupuliformis Sartw.
Carex squarrosa L.
Carex lurida Wahl.

Araceae
Arisaema atrorubens (Ait.) Blume
Arisaema dracontium (L.) Schott
Peltandra virginica (L.) Kunth
Acorus calamus L.

Commelinaceae
Tradescantia canaliculata Raf.
Tradescantia virginiana L.
Commelina communis L.

Juncaceae
Juncus effusus L.
Juncus macer S.F. Gray
Juncus marginatus Rostk.
Juncus torreyi Coville
Juncus acuminatus Michx.
Luzula multiflora (Ehrh.) Lej.

Liliaceae
Allium canadense L.
Allium stellatum Ker
Nothoscordum bivalve (L.) Britt.
Hemerocallis fulva L.
Erythronium americanum Ker
Erythronium albidum Nutt.
Camassia scillioides (Raf.) Cory
Ornithogallum umbellatum L.
Asparagus officinalis L.
Smilacina racemosa (L.) Desf.
Uvularia grandiflora Sm.
Polygonatum biflorum (Walt.) Ell.
Stenanthium gramineum (Ker) Morong.
Trillium sessile L.
Trillium recurvatum Beck
Trillium grandiflorum (Mich.) Salisb.
Smilax hispida Muhl.
Smilax pulverulenta Michx.

Amaryllidaceae
Agave virginica L.
Hypoxis hirsuta (L.) Coville

Iridaceae
Iris shrevei Small
Iris fulva Ker
Iris cristata Ait.
Sisyrinchium albidum Raf.

Orchidaceae
Cypripedium parviflorum Salisb.
Orchis spectabilis L.
Habenaria peramoena Gray
Calapogon pulchellus (Salisb.) R. Br.
Liparis liliifolia (L.) Rich.
Aplectrum hyemale (Muhl.) Torr.
Corallorrhiza wisteriana Conrad

Saururaceae
Saururus cernuus L.

Salicaceae
Populus heterophylla L.
Populus deltoides Marsh.
Salix nigra Marsh.
Salix cordata Muhl.
Salix humilis Marsh.

Juglandaceae
Juglans cinerea L.
Juglans nigra L.
Carya illinoensis (Wang.) K. Koch
Carya cordiformis (Wang.) K. Koch
Carya tomentosa Nutt.
Carya ovata (Mill.) K. Koch

Betulaceae
Betula nigra L.
Alnus rugosa (Duroi) Spreng.
Corylus americana Walt.
Carpinus caroliniana Walt.
Ostrya virginiana (Mill.) K. Koch

Fagaceae
Fagus grandifolia Ehrh.
Quercus imbricaria Michx.
Quercus phellos L.
Quercus marilandica Muench.
Quercus rubra L.
Quercus rubra, var. pagodaefolia Ashe
Quercus borealis Michx. f.
Quercus palustris Muench.
Quercus shumardii Buckl.
Quercus velutina Lam.
Quercus alba L.
Quercus stellata Wang.
Quercus macrocarpa Michx.
Quercus lyrata Walt.
Quercus muhlenbergii Engelm.
Quercus prinus L.
Quercus montana Willd.
Quercus bicolor Willd.

Ulmaceae
Ulmus americana L.
Ulmus alata Michx.
Ulmus fulva Michx.
Planera aquatica (Walt.) J.F. Gmel.
Celtis occidentalis L.
Celtis laevigata Willd.

Urticaceae
Urtica chamaedryoides Pursh
Boehmeria cylindrica (L.) Sw.
Pilea pumila (L.) Gray
Laportea canadensis (L.) Gaud.

Santalaceae
Comandra umbellata (L.) Nutt.

Loranthaceae
Phoradendron flavescens (Pursh) Nutt

Aristolochiaceae
Aristolochia tomentosa Sims
Asarum reflexum Bickn.

Polygonaceae
Rumex acetosella L.
Rumex altissimus Wood
Rumex verticillatus L.
Rumex crispus L.
Rumex obtusifolius L.
Rumex fueginus Phil.
Polygonum aviculare L.
Polygonum pennsylvanicum L.
Polygonum lapathifolium L.
Polygonum hydropiperoides Michx.
Polygonum periscaria L.
Polygonum virginianum L.
Polygonum sagittatum L.
Polygonum scandens L.
Brunnichia cirrhosa Gaertn.

Chenopodiaceae
Chenopodium album L.
Chenopodium ambrosioides L.
Chenopodium hybridum L.

Amaranthaceae
Amaranthus spinosus L.
Amaranthus retroflexus L.
Amaranthus blitoides Wats.
Froelichia campestris Small

Phytolaccaceae
Phytolacca americana L.

Nyctaginaceae
Mirabilis nyctaginea (Michx.) MacM.

Portulacaceae
Claytonia virginica L.
Portulaca oleracea L.

Caryophyllaceae
Cerastium nutans Raf.
Stellaria media (L.) Cyrill.
Stellaria longifolia Muhl.
Silene antirrhina L.
Silene stellata (L.) Ait.
Saponaria officinalis L.

Magnoliaceae
Magnolia acuminata L.
Liriodendron tulipifera L.

Annonaceae
Asimina triloba (L.) Dunal.

Ranunculaceae
Isopyrum biternatum (Raf.) T. & G.
Aquilegia canadensis L.
Actaea alba (L.) Mill.
Delphinium tricorne Michx.
Myosurus minimus L.
Ranunculus flabellaris Raf.
Ranunculus oblongifolius Ell.
Ranunculus abortivus L.
Ranunculus micranthus Nutt.
Ranunculus pusillus Poir.
Ranunculus septentrionalis Poir.
Ranunculus fascicularis Muhl.
Ranunculus hispidus Michx.
Ranunculus parvulus L.
Thalictrum revolutum DC.
Anemone virginiana L.
Anemonella thalictroides (L.) Spach.
Hepatica acutiloba DC.
Clematis pitcheri T. & G.

Nelumbonaceae
Nelumbo lutea (Willd.) Pers.

Nymphaeaceae
Nuphar advena Ait.

Ceratophyllaceae
Ceratophyllum demersum L.

Berberidaceae
Podophyllum peltatum L.
Caulophyllum thalictroides (L.) Michx.

Menispermaceae
Cocculus carolinus (L.) DC.

Lauraceae
Sassafras albidum (Nutt.) Nees
Lindera benzoin (L.) Blume

Papaveraceae
Sanguinaria canadensis L.
Stylophorum diphyllum (Michx.) Nutt

Fumariaceae
Dicentra cucullaria (L.) Bernh.
Corydalis flavula (Raf.) DC.

Cruciferae
Brassica arvensis (L.) Rabenh.
Barbarea vulgaris R. Br.
Rorippa palustris (L.) Besser
Sisymbrium officinale (L.) Scop.
Sisymbrium altissimum L.
Descurainia brachycarpa (Richards) O.E. Schulz
Draba brachycarpa Nutt.
Draba verna L.
Dentaria laciniata Muhl.
Cardamine bulbosa (Schreb.) BSP.
Cardamine pennsylvanica Muhl.
Cardamine arenicola Britt.
Arabis virginica (L.) Poir.
Arabis laevigata (Muhl.) Poir.
Arabidopsis thaliana (L.) Heynh.
Nasturtium officinale R. Br.
Neobeckia aquatica (Eaton) Greene
Lepidium virginicum L.
Thlaspi arvense L.
Capsella bursa-pastoris (L.) Medic.

Capparidaceae
Polanisia graveolens Raf.

Crassulaceae
Sedum pulchellum Michx.
Sedum ternatum Michx.
Sedum telephioides Michx.
Penthorum sedoides L.

Saxifragaceae
- Heuchera parviflora Bartl.
- Heuchera hirsuticaulis (Wheelock) Rydb.
- Saxifraga virginiensis Michx.

Hydrangeaceae
- Hydrangea arborescens L.

Grossulariaceae
- Ribes cynosbati L.

Hamamelidaceae
- Liquidambar styraciflua L.

Platanaceae
- Platanus occidentalis L.

Rosaceae
- Gillenia stipulata (Muhl.) Trel.
- Potentilla recta L.
- Potentilla monspeliensis L.
- Potentilla simplex Michx.
- Geum canadense Jacq.
- Agrimonia rostellata Wallr.
- Rubus occidentalis L.
- Rubus allegheniensis Porter
- Rubus argutus Link
- Rubus flagellaris Willd.
- Amelanchier arborea (Michx. f.) Fern.
- Malus ioensis (Wood) Britt.
- Prunus americana Marsh.
- Prunus hortulana Bailey
- Prunus serotina Ehrh.
- Rosa setigera Michx.
- Rosa carolina L.

Leguminosae
- Desmanthus illinoensis Michx. MacM.
- Cercis canadensis L.
- Gymnocladus dioica (L.) K. Koch
- Gleditsia triacanthos L.
- Gleditsia aquatica Marsh.
- Cassia marilandica L.
- Cassia nictitans L.
- Baptisia leucantha T. & G.
- Crotalaria sagittalis L.
- Trifolium reflexum L.
- Trifolium repens L.
- Trifolium hybridum L.
- Trifolium pratense L.
- Trifolium procumbens L.
- Melilotus officinalis (L.) Lam.
- Melilotus alba Desr.
- Tephrosia virginiana (L.) Pers.
- Robinia pseudo-acacia L
- Desmodium pauciflorum (Nutt.) DC.
- Desmodium glutinosum (Muhl.) Wood
- Desmodium nudiflorum (L.) DC.
- Desmodium illinoense Gray
- Desmodium dillenii Darl.
- Desmodium marilandicum (L.) DC.
- Desmodium ciliare DC.
- Desmodium canadense (L.) DC.
- Lespedeza repens (L.) Bart.
- Lespedeza procumbens Michx.
- Lespedeza violacea (L.) Pers.
- Lespedeza virginica (L.) Britt.
- Lespedeza striata (Thunb.) H. & A.
- Stylosanthes biflora (L.) BSP.
- Apios americana Medic.
- Phaseolus polystachys (L.) BSP.
- Strophostyles helvola (L.) Britt.
- Strophostyles leiosperma (T. & G.) Piper
- Clitoria mariana L.
- Amphicarpa comosa (L.) G. Don
- Galactia mississippiensis (Vail) Rydb.

Geraniaceae
- Geranium maculatum L.
- Geranium carolinianum L.

Oxalidaceae
- Oxalis violacea L.
- Oxalis stricta L.
- Oxalis cymosa Small

Linaceae
- Linum medium (Planch.) Britt.

Balsaminaceae
- Impatiens biflora Walt.
- Impatiens pallida Nutt.

Polygalaceae
- Polygala sanguinea L.

Euphorbiaceae
- Croton capitatus Michx.
- Acalypha gracilens Gray
- Chamaesyce maculata (L.) Small
- Chamaesyce supina (Raf.) Moldenke
- Euphorbia corollata L.
- Euphorbia marginata Pursh
- Poinsettia dentata (Michx.) Small

Celastraceae
- Celastrus scandens L.
- Euonymus atropurpureus Jacq.

Aquifoliaceae
- Ilex decidua Walt.

Anacardiaceae
- Rhus copallina L.
- Rhus glabra L.
- Rhus radicans L.
- Rhus aromatica Ait.

Staphyleaceae
- Staphylea trifolia L.

Aceraceae
- Acer saccharinum L.
- Acer rubrum L.
- Acer saccharum Marsh.
- Acer nigrum Michx. f.
- Acer negundo L.

Aesculaceae
- Aesculus glabra Willd.
- Aesculus discolor Pursh

Rhamnaceae
- Ceanothus americanus L.

Vitaceae
- Vitis aestivalis Michx.
- Ampelopsis arborea (L.) Koehne
- Parthenocissus quinquefolia (L.) Planch.

Tiliaceae
- Tilia americana L.

Malvaceae
Sida spinosa L.
Hibiscus militaris Cav.
Hibiscus lasiocarpos Cav.

Hypericaceae
Hypericum punctatum Lam.
Ascyrum multicaule Michx.
Triadenum virginicum (L.) Raf.

Violaceae
Hybanthus concolor (Forst.) Spreng.
Viola pedata L.
Viola falcata Greene
Viola papilionacea Pursh
Viola missouriensis Greene
Viola sororia Willd.
Viola eriocarpa Schw.
Viola striata Ait.
Viola rafinesquii Greene
Viola viarum Pollard

Passifloraceae
Passiflora lutea L.

Lythraceae
Rotala ramosior (L.) Koehne
Decodon verticillatus (L.) Ell.
Lythrum alatum Pursh
Cuphea petiolata (L.) Koehne

Onagraceae
Jussiaea diffusa Forsk.
Ludwigia alternifolia L.
Oenothera biennis L.
Oenothera laciniata Hill
Oenothera pilosella Raf.
Oenothera speciosa Nutt.
Oenothera linifolia Nutt.
Circeaea latifolia Hill

Cornaceae
Cornus racemosa Lam.
Cornus florida L.
Nyssa sylvatica Marsh.
Nyssa aquatica L.

Araliaceae
Aralia spinosa L.
Aralia racemosa L.

Umbelliferae
Eryngium yuccifolium Michx.
Daucus carota L.
Torilis japonicus (Houtt.) DC.
Sanicula marilandica L.
Sanicula canadensis L.
Osmorhiza longistylis (Torr.) DC.
Cryptotaenia canadensis (L.) DC.
Erigenia bulbosa (Michx.) Nutt
Chaerophyllum procumbens (L.) Crantz
Conium maculatum L.
Sium cicutaefolium Gmel.
Cicuta maculata L.
Thaspium sylvaticum (Benke) n. comb.
Polytaenia nuttallii DC.

Ericaceae
Monotropa uniflora L.
Rhododendron roseum (Loisel.) Rehd.
Vaccinium vacillans Kalm

Primulaceae
Lysimachia nummularia L.
Lysimachia ciliata L.
Lysimachia lanceolata Walt.
Dodecatheon meadia L.
Dodecatheon frenchii (Vasey) Rydb.

Ebenaceae
Diospyros virginiana L.

Styracaceae
Styrax americana Lam.

Oleaceae
Fraxinus americana L.
Fraxinus lanceolata Borkh.
Forestiera acuminata Poir.

Loganiaceae
Spigelia marylandica L.

Gentianaceae
Sabatia angularis (L.) Pursh
Obolaria virginica L.

Apocynaceae
Amsonia tabernaemontana Walt.
Apocynum cannabinum L.

Asclepiadaceae
Asclepias tuberosa L.
Asclepias syriaca L.
Asclepias purpurascens L.
Asclepias incarnata L.
Asclepias perennis Walt.
Acerates hirtella Pennell
Ampelamus albidus (Nutt.) Britt.
Asclepiodora viridis (Walt.) Gray

Convolvulaceae
Convolvulus americanus (Sims) Greene
Convolvulus arvensis L.
Ipomoea pandurata (L.) G.F.W. Mey.
Ipomoea lacunosa L.
Ipomoea purpurea (L.) Roth
Ipomoea hederacea Jacq.
Cuscuta pentagona Engelm.
Cuscuta polygonorum Engelm.

Polemoniaceae
Phlox paniculata L.
Phlox glaberrima L.
Phlox pilosa L.
Phlox divaricata L.
Phlox bifida Beck
Polemonium reptans L.

Hydrophyllaceae
Hydrophyllum appendiculatum Michx.
Phacelia bipinnatifida Michx.
Phacelia purshii Buckl.
Hydrolea affinis Gray

Boraginaceae
Heliotropium indicum L.
Mertensia virginica (L.) Link
Myosotis verna Nutt.
Lithospermum canescens (Michx.) Lehm.
Lithospermum arvense L.

Verbenaceae
Verbena bracteata Lag. & Rodr.
Verbena urticaefolia L.

Verbena stricta Vent.
Verbena hastata L.
Verbena simplex Lehm.
Phyla lanceolata (Michx.) Greene

Labiatae
Teucrium canadense L.
Scutellaria lateriflora L.
Scutellaria ovata Hill
Scutellaria ovalifolia Michx.
Scutellaria incana Spreng.
Scutellaria nervosa Pursh
Marrubium vulgare L.
Agastache nepetoides (L.) Ktze.
Nepeta cataria L.
Physostegia virginiana (L.) Benth.
Prunella vulgaris L.
Leonurus cardiaca L.
Stachys tenuifolia Willd.
Blephilia hirsuta (Pursh) Torr.
Monarda bradburiana Beck
Monarda fistulosa L.
Hedeoma pulegioides (L.) Pers.
Pycnanthemum pycnanthemoides (Leavenw.) Fern.
Pycnanthemum flexuosum (Walt.) BSP.
Cunila origanoides (L.) Britt.
Lycopus rubellus Moench.
Lycopus americanus Muhl.
Perilla frutescens (L.) Britt.

Solanaceae
Physalis pubescens L.
Datura stramonium L.
Solanum carolinense L.
Solanum rostratum Dunal
Solanum nigrum L.

Scrophulariaceae
Verbascum thapsus L.
Chelone obliqua L.
Pentstemon hirsutus (L.) Willd.
Pentstemon pallidus Small
Pentstemon digitalis Nutt.
Pentstemon tubaeflorus Nutt.
Collinsia verna Nutt.
Linaria vulgaris Mill.
Lindernia dubia (L.) Pennell
Gratiola virginiana L.
Mimulus alatus Soland.
Bacopa rotundifolia (Michx.) Wettst.
Veronicastrum virginicum (L.) Farw.
Veronica peregrina L.
Veronica arvensis L.
Aureolaria flava (L.) Farw.
Gerardia paupercula Gray
Gerardia tenuifolia Vahl
Dasistoma macrophylla (Nutt.) Raf.
Pedicularis canadensis L.

Lentibulariaceae
Utricularia gibba L.

Orobanchaceae
Epifagus virginiana (L.) Bart.
Orobanche unifora L.

Bignoniaceae
Catalpa speciosa Warder
Bignonia capreolata L.
Campsis radicans (L.) Seem.

Acanthaceae
Ruellia ciliosa Pursh
Ruellia pedunculata Torr.

Phrymaceae
Phryma leptostachya L.

Plantaginaceae
Plantago rugelii Dene.
Plantago lanceolata L.
Plantago aristata Michx.

Rubiaceae
Houstonia caerulea L.
Houstonia lanceloata (Poir) Britt.
Cephalanthus occidentalis L.
Diodia teres Walt.
Diodia virginiana L.
Spermacoce glabra Michx.
Galium aparine L.
Galium circaezans Michx.
Galium concinuum T. & G.
Galium obtusum Bigel.
Galium tinctorium L.

Caprifoliaceae
Sambucus canadensis L.
Symphoricarpos orbiculatus Moench.
Lonicera japonica Thunb.
Triosteum angustifolium L.

Valerianaceae
Valerianella radiata (L.) Dufr.

Cucurbitaceae
Sicyos angulatus L.

Campanulaceae
Campanula americana L.
Campanula intercedens Witasek
Specularia perfoliata (L.) A.DC.

Lobeliaceae
Lobelia cardinalis L.
Lobelia siphilitica L.
Lobelia inflata L.

Compositae
Iva ciliata Willd.
Ambrosia elatior L.
Ambrosia trifida L.
Ambrosia bidentata Michx.
Xanthium pennsylvanicum Wallr.
Vernonia altissima Nutt.
Vernonia missurica Raf.
Elephantopus carolinianus Willd.
Eupatorium purpureum L.
Eupatorium serotinum Michx.
Eupatorium rugosum Houtt.
Eupatorium coelestinum L.
Mikania scandens (L.) Willd.
Liatris squarrosa (L.) Willd.
Liatris bebbiana Rydb.
Chrysopsis villosa (Pursh) Nutt.
Solidago caesia L.

Solidago rugosa Mill.
Solidago nemoralis Ait.
Solidago drummondii T. & G.
Solidago altissima L.
Solidago speciosa Nutt.
Solidago speciosa rigidiuscula T. & G.
Solidago rigida L.
Boltonia asteroides (L.) L'Her.
Aster anomalus Engelm.
Aster shortii Lindl.
Aster cordifolius L.
Aster drummondii Lindl.
Aster sagittifolius Wedem.
Aster novae angliae L.
Aster turbinellus Lindl.
Aster ericoides L.
Aster salicifolius Lam.
Aster interior Wieg.
Aster lateriflorus (L.) Britt.
Aster patens Ait.
Erigeron pulchellus Michx.
Erigeron philadelphicus L.
Erigeron strigosus Muhl.
Erigeron annuus (L.) Pers.
Erigeron divaricatus Michx.
Erigeron canadensis L.
Pluchea camphorata (L.) DC.
Antennaria plantaginifolia Hook.
Gnaphalium obtusifolium L.
Silphium terebinthinaceum Jacq.
Silphium laciniatum L.
Silphium Silphium integrifolium Michx.
Silphium perfoliatum L.
Parthenium integrifolium L.
Heliopsis helianthoides (L.) Sweet
Eclipta alba (L.) Hassk.
Rudbeckia hirta L.
Rudbeckia subtomentosa Pursh
Galinsoga ciliata (Raf.) Blake
Helianthus strumosus L.
Helianthus tuberosus L.
Helianthus maximiliani Schrad.
Actinomeris alternifolia (L.) DC.
Verbesina helianthoides Michx.
Coreopsis pubescens L.
Coreopsis tripteris L.
Bidens comosa (Gray) Wieg.
Bidens aristosa (Michx.) Britt.
Helenium nudiflorum Nutt.
Helenium tenuifolium Nutt.
Achillea millefolium L.
Anthemis cotula L.
Chrysanthemum leucanthemum L.
Cacalia atriplicifolia L.
Senecio plattensis Nutt.
Senecio aureus L.
Senecio glabellus Poir.
Arctium minus (Hill) Bernh.
Cirsium vulgare (Savi) Airy-Shaw
Cirsium discolor (Muhl.) Spreng.
Cirsium altissimum (L.) Spreng.
Serinia oppositifolia (Raf.) Ktze.
Krigia dandelion (L.) Nutt.
Krigia biflora (Walt) Blake
Lactuca scariola L.
Lactuca canadensis L.
Lactuca floridana (L.) Gaertn.
Pyrrhopappus carolinianus (Walt.) DC.
Taraxacum vulgare (Lam.) Schrank

FERNS OF ROCK RIVER VALLEY IN ILLINOIS*

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The purpose of this paper is to give some account of the fern habitats and of the present fern population of the drainage basin of Rock River from the Wisconsin state line to Dixon, a distance of fifty miles. The area includes Boone, Winnebago, eastern Stephenson, western Ogle and a part of Lee Counties. This is a glaciated, partly wooded but mostly prairie area where the streams have cut hills, cliffs and ravines which with their bordering woods, the sandy area in northeastern Winnebago County and the sandstone area in Ogle County, provide the diversification of soil and terrain necessary for the formation of differing fern habitats. The woods are mostly an oak-hickory association. The rock outcrops are small and infrequent except along Kishwaukee and Rock Rivers. They are of Galena dolomite and Plattville limestone except in Ogle County where there is a considerable exposure of St. Peter sandstone along Rock River. In northern Boone County there are peaty bog areas, and in the sand area in Winnebago County there are boggy areas with Sphagnum and northern plants that are not found elsewhere in this region.

The fern habitats in the area are: sandstone outcrops and ravines, exposed and shaded; limestone outcrops and ravines, exposed and shaded; slough marshes and bog areas; bottomland woods and upland woods. The species growing typically on sandstone are *Woodsia obtusa, Woodsia ilvensis, Polypodium virginianum, Dryopteris disjuncta* and *Dryopteris phegopteris.* Those growing typically on limestone are *Cystopteris bulbifera, Camptosorus rhizophyllus, Cryptogramma stelleri* and *Pellaea glabella.* Typically inhabiting marshes and other wet places are *Osmunda regalis, Osmunda cinnamomea, Osmunda claytoniana, Onoclea sensibilis, Pteretis struthiopteris, Dryopteris thelypteris* and *Dryopteris cristata.* Typical of woods are *Botrychium dissectum, Botrychium obliquum, Botrychium multifidum, Botrychium virginianum, Cystopteris fragilis, Polystichum acrostichoides, Dryopteris hexagonoptera, Dryopteris marginalis, Dryopteris intermedia, Dryopteris spinulosa, Asplenium platyneuron, Athyrium angustum, Athyrium thelypterioides, Adiantum pedatum* and *Pteridium latiusculum.* This list of species known to grow in this area does not account for all the ferns found in Northern Illinois, because the unglaciated area in Jo Daviess County with its Fee fern and the Lake County bog with the Virginia chain fern are not included. Few of our species are common and there are only a few areas where ferns are abundant. Specimens of each species are deposited in the herbarium of the Illinois State Mu-

* The field work was done by the authors over the past five years with collaboration of George D. Fuller whose help is greatly appreciated.

seum. The nomenclature is that of Jones.[1]

Botrychium dissectum Spreng. The cut-leaved grape fern is known in only one station in this area. It grows in an upland black oak woods on the Winnebago-Boone County line where there is a colony of considerable size in close association with the next species. The plants of both species in this colony are all small, equally fertile, equally bronzed, and look much alike except for the leaf cutting. In *B. dissectum* the leaf segments are laciniate but there is some variation in this.

Botrychium obliquum Muhl. The oblique grape fern is generally distributed over this area but is found less frequently than the next species. It is most frequent in the sand area of northern Winnebago County and in the sandstone area in Ogle County. It is usually found as an individual but occasionally there are several plants in a small area. It is at times found in unusual situations, as an open pasture, a roadside, the middle of a parking space in a forest preserve. It is of thinner texture and the stem is more slender than in *B. multifidum*. The leaf segments are few and the serrations are acute.

Botrychium multifidum (S. G. Gmel.) Rupr. The leathery grape fern seems to be more frequent in this area than the preceding but is of the same distribution preferring the sandy areas. The ultimate leaf segments are crowded and are obtuse.

The above three species have much in common. They inhabit woods, starting to grow in late June. The blade is fully developed by September. The sporophyll ripens and withers quickly but the blade persists over winter, often staying green and fresh until after the second year's blade is well developed. We have had a number of grape ferns under observation for several years. Some of them are large, some small, and they seem to remain so although individual plants vary somewhat in size from year to year. The size of the plant has little to do with whether it has spores. There seems to be no difference as to size, bronzing, or other growth habits. They are practically identical except for the cutting of the leaf blades.

Botrychium virginianum (L.) S. M. The rattlesnake fern is generally distributed and is common over the area, growing especially on sandy hillsides in woods, shade being the primary requirement, moisture secondary. It starts to grow about April 20th in the average spring and is very sensitive to frost. There is a material difference in the size of plants, the small ones sporulating about as often as the large. In our area the difference in the fineness of leaf cutting is not marked enough to justify separation into varieties.

Osmunda regalis L. The royal fern grows in the sandy area of northern Winnebago County but we have not found it elsewhere in this area. Though usually found with the two other osmundas in typical situations it is not uncommon for the two others to be plentiful and this fern absent. It does not cover a large area anywhere. Growth starts in late March. It sporulates better in the sun. In the field the brown sporophylls are conspicuous

[1] Jones, G. N. "An Enumeration of Illinois Pteridophyta." Am. Mid. Nat., Vol 38, No. 1, pp. 76-126, July 1947.

but at a distance are easily mistaken for the fruiting panicles of Rumex.

Osmunda cinnamomea L. The cinnamon fern is found in the north Winnebago County sand area but is much more plentiful and grows more robustly in shaded ravines in the Ogle County sandstone area where it is associated with *O. claytoniana.* It is much less plentiful than the latter. It grows on the east face of Castle Rock in a dry exposed situation where it is plentiful but the plants are small. Growth begins the latter part of March though it is quite sensitive to frost. The sporophylls grow, ripen and disappear quickly before the leaves are fully grown; not all plants have spores every year.

Osmunda claytoniana L. The interrupted fern is our most common osmunda. It grows preferably in wet sandy situations but it is also found on the wooded bank of Kishwaukee River in a limestone region. Its moisture requirement is less than that of the other osmundas but it does not grow as robustly in dry places. Growth starts about April 1st in an average season.

Onoclea sensibilis L. The sensitive fern is found all over this area, and although a weed so far as looks and use are concerned it is nowhere common enough to be a nuisance. It prefers wet open places but is also found in woods that are not particularly wet. Growth starts about April 15th and being very sensitive to frost it often has to make several starts.

Pteretis struthiopteris (Michx.) Nieuw. The ostrich fern is quite uncommon here. In a ravine in the sandstone area in Ogle county are three colonies growing in the shade in a floodplain situation. It is not known to occur elsewhere in the area. It seems to sporulate better in the sun. It is readily found in winter by the stiffly erect sporophylls which form in late summer.

Cystopteris fragilis (L.) Bernh. The brittle fern is common over the area. It is usually found in moist woods but also on shaded limestone and to a lesser extent on shaded sandstone. With the lady fern it is the first to appear in the spring and it is not very sensitive to frost. It does not stand our dry summers well and often dries up, starting again when rain and cooler weather come. There is an extreme variation in vegetative features in different situations. Plants growing in loose soil in woods have long branching rhizomes and the growing point protrudes and is naked; on rock the growth is less luxuriant, the rhizome is short as is the growing point which is more or less covered with scales. Much sun causes prolific sporulation.

Cystopteris bulbifera (L.) Bernh. The bulblet fern grows in this area wherever its favorite habitat, moist shaded limestone, occurs. It is also found on shaded stream banks, especially in Kishwaukee River gorge. It grows less well on sandstone. Growth begins about April 1st. The young plants have red stipes which separate it in early infancy from *C. fragilis.* It is not subject to vegetative variations except that, its moisture requirement being high, drought causes depauperate plants.

Woodsia obtusa (Spreng.) Torr. The common woodsia is not common in this area. It is seldom found on limestone and here it does not grow on wooded hillsides to nearly the

extent that it does in more southern counties. It grows on a high sandy slough bank in Boone County and on limestone in White Pines State Park, but otherwise it is confined to the sandstone area of Ogle County. It is not uncommon on partly shaded cliffs but grows larger when in humus in woods. It is our only fern that grows throughout the winter. In the dry weather of late summer the plants may become dormant, the leaves turning yellowish and the edges curling back.

Woodsia ilvensis (L.) R. Br. The rusty woodsia is found in a number of stations in the sandstone area of Ogle County but it does not occur elsewhere in this region. It is often accompanied by *W. obtusa* which it does not resemble enough to be confusing. It grows about four inches tall in compact mats on the top edge of exposed outcrops so that it is not difficult to find. In one place in the sandstone area it grows on a shaded sandy hillside and here it is larger than in its typical situation. It can be found in winter by its characteristic stubble. It is sensitive to late frosts but quickly starts growing again. In dry weather it tends to curl but is quickly rejuvenated by rain.

Polystichum acrostichoides (Michx.) Schott. The Christmas fern has not been found by us in the area but there are specimens in the State Museum and University of Illinois herbaria from White Pines State Park in Ogle County. The nearest place outside this area that we have seen it is Starved Rack State Park in LaSalle County.

Dryopteris disjuncta (Leleb.) Morton. The oak fern grows on a moist partly shaded sandstone outcrop near Oregon in Ogle County with *Cornus canadensis, Trientalis borealis* and *Pinus strobus,* northern species which are very rare here. This station is probably the same from which M. B. Waite 60 years ago collected his specimens that are now in the University of Illinois herbarium. It is a small patch on a steep cliff, and the plants are healthy so its chances of continuing to survive are good. The nearest outside stations are in Green County, Wisconson, and in St. Clair County, Illinois.

Dryopteris phegopteris (L.) C. Chr. The long beech fern prefers wet shaded sandstone and is in such a situation in the two stations we have found in Ogle County where it is accompanied by *Viola pallens* which is rare here. Our plants do not look at all like *D. hexagonoptera.* The blade of *D. phegopteris* is definitely smaller and narrower, it has a distinctly yellow cast, and is more hairy. The croziers are very woolly and brown. It starts growing earlier than *D. spinulosa* and *D. intermedia.* The bending of the blade and the deflexion of the inferior pinnae are noticeable very early.

Dryopteris hexagonoptera (Michx.) C. Chr. The broad beech fern is found in one small station in a wooded ravine in the sandstone area of Ogle County. It is a much more robust plant than *D. phegopteris.* The winging of the rachis between the first and second pairs of pinnae is always so definite as to leave no doubt as to the species. The characteristic deflexion and turning forward and inward of the inferior pinnae is not seen in dried plants.

Dryopteris thelypteris (L.) Gray. The marsh fern in this region grows mostly in the bog areas of northern Winnebago and Boone Counties in its proper habitat, but we have also found it in abnormal situations such as a dry sunny sandstone outcrop in Camp Lowden, Ogle County, in a rather dry woods in White Pines State Park, and in Winnebago County, and on a dry railroad bank in Boone County. Under such conditions it sporulates sparingly and the blades are a different shape, the lower pinnae instead of being longer tend to shorten progressively and to become more remote, thus giving the appearance of *D. noveborensis;* but the veins are forked. Growth begins the latter part of April and the leaves are still very immature in early June. The sporophylls develop the latter part of July, abundantly in open wet places but less so in dry places or in the shade.

Dryopteris marginalis (L.) Gray. The marginal wood fern is found in this area only in White Pines State Park in Ogle County where the plants are large and healthy but are few. It is common at Starved Rock in LaSalle County and also occurs in Apple River Canyon State Park. The leaves stay green and erect all winter. The number of sori varies greatly on different plants without apparent cause.

Dryopteris cristata (L.) Gray. The crested wood fern grows in White Pines State Park and in a ravine near Oregon in Ogle County, in several places in Winnebago County but it is most abundant in the boggy area in northern Boone County. We have found it in woods and in ravines but for the most part it is a bog plant. There are never more than a few plants in one place. It is the first of the wood ferns to start growing in the spring. The sterile blades and the sterile part of partly fruited blades are evergreen. There is considerable difference in the length and width of the blades on different plants but otherwise there is no important variation.

Dryopteris intermedia (Muhl.) Gray. The common wood fern is not the common one in this region. It is found in all our counties, the distribution being much the same as of *D. spinulosa* but it is much less common than the latter. The gradation with *D. spinulosa* is not apparent in our plants. It tends to grow in drier plices; the leaf is more finely divided and is thinner; the shortening of the proximal inferior pinnule on the lowest pinna is definite, and the leaves of this plant do not flop over so quickly after freezing. Spring growth starts after April 15th.

Dryopteris spinulosa (O. F. Muell.) Watt. The spinulose wood fern grows in moist woods and ravines in all our counties. We have found it in a bog in the open in northern Boone County. Robust plants have broad blades and the lower proximal pinnule on the basal pinna is much enlarged and elongated but there is no sharp dividing line between this and the typical form in our area. This fern starts growth the same time as *D. intermedia.* After the first hard frost the plant is inactive until spring, the bases of the stems soften and the leaves lie flat on the ground, staying green all winter. It is a coarser looking plant than *D. intermedia.*

Polypodium virginianum L. The common polypody in this area is abundant on the sandstone in Ogle County but otherwise we have found it in only one small station, in a limestone situation in Kishwaukee River gorge in Winnebago County. Its vegetative characters are not subject to variation. Growth starts about April 1st, the fronds being well uncoiled when still quite small.

Camptosorus rhizophyllus (L.) Link. The walking fern is found in all the counties of this area on moist shaded limestone. We have found it growing on sandstone on Franklin Creek in Lee County. In one of our largest stations in a Kishwaukee River ravine where the environment seems correct it is of a depauperate type, the plant having a juvenile appearance with blunt blades. In dry situations the edges of the blades are wavy and irregular. We have found but few blades lacking auricles. It is evergreen and spring growth starts about April 1st.

Asplenium platyneuron (L.) Oakes. The ebony spleenwort is quite uncommon in this area. We have found it in several places in Ogle County and in Boone County. Many years ago we found it in Winnebago County but we are now unable to locate it. Its favorite habitat here is shaded sandstone, but on Castle Rock in what looks like a favorable situation it is small compared with those growing in woods in a limestone area in White Pines State Park.

Athyrium angustum (Willd.) Presl. The lady fern is a common fern here, growing in practically all moist woods, in ravines, at the edge of open marshy places, and by accident on cliffs. There is a great variation in the size of the plants, the color of the stipes, cutting of the blades, size and shape of the sori, etc., which seems to depend on environmental conditions. Though the first with *Cystopteris fragilis* to start growing in the spring, it is very tender to fall frosts. It does not withstand hot dry weather.

Athyrium thelypterioides (Michx.) Desv. The silvery glade fern is known in our area from Winnebago and Ogle Counties. The nearest outside station that we know is Mississippi Palisades State Park. In our plants the lower surface of the pubescent. This and the silvery streaks the sori make very early in their development are the most noticeable field points.

Cryptogramma stelleri (S. G. Gmel.) Prantl. The slender cliff brake is found across northern Illinois wherever its habitat, moist shaded limestone, occurs. It is in all our counties. We have not found it in Kishwaukee River gorge in places that look favorable. It is our smallest and most fragile fern. It is difficult to find, for though it starts to grow early in April, the sterile blades have begun to turn yellow by late May and soon disappear. The sporophylls are a little more persistent but by the last of July they are very hard to find. In a mild wet fall a second growth of sterile leaves appears in October.

Pellaea glabella Mett. The smooth cliff brake is found in this area on practically all exposed limestone outcrops. It also grows on small rocks on hillsides, in railroad cuts, in old quarries and on bridge abutments. It is evergreen in the sense that it

retains its peculiar bluish green color well into the second year. After the pinnules are shed the old stipes persist stiffly erect for years. It prefers a dry exposed situation but if the cliff is excessively dry the plants though plentiful are small. When it grows in a moist shady place the plants are larger and more abundant. We have found it growing on sandstone only once, on the river side of Castle Rock in Ogle County where it is of a depauperate type. Growth starts about April 1st, the leaves developing slowly.

Adiantum pedatum L. The Maidenhair fern grows in large or small patches in most of the moist rich woods in this area but it is strangely absent from some woods that seem suitable. It occurs by accident on moist cliffs. Growth starts early in April and it is the last of our deciduous ferns to be killed by frost in the fall. It is not subject to variations except as to size.

Pteridium latiusculum (Desv.) Hieron. The bracken is another common fern which is generally distributed over this area, growing preferably in sandy oak woods but also along roadsides, railroads, and in brushy pastures. It spreads rapidly and forms large patches. It is a stately plant that starts to grow about April 1 by the appearance of three greenish balls on a stem which are very sensitive to frost, so it is not uncommon in a late spring for several starts to be made. This does not seem to retard the later development of the plant. The cutting of the leaves varies from plant to plant and even on the same rhizome. Variations are not sufficient to justify separation into varieties. It is our one fern that is truly a weed.

Summary

The geography and topography of a well defined area in northern Illinois, the drainage basin of Rock River, is described and some account of the habitats and fern inhabitants of the area is given.

The frequency of occurrence and distribution of each of the 31 species that we know to grow in the area are given.

Some comments are made about the growth habits and the local peculiarities of each of the species as observed in the field.

EMBRYO DEVELOPMENT OF THE POND CYPRESS (*TAXODIUM ASCENDENS BRONGN.*)*

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Collections of material for this study were made in Collier County, Florida, along the Tamiami Trail (U. S. Highway 94) in August of 1947 and May of 1948. Since it has been stated (Davis, 1943) that the pond cypress, *Taxodium ascendens* Brongn., growing in this region could possibly be a variety of the bald cypress, *T. distichum* (L.) Rich., care was used in the examination of all trees sampled. Rehder (1947) makes use of the differences in the leaf shape and arrangement and habit of growth of the branchlets in separating these two plants in his manual and recognizes *T. ascendens* as a valid species. Certainly the subulate leaves, incurved and closely appressed to the twigs, and the more upright growth of the branchlets of the pond cypress are all characteristics in marked contrast to the linear, spreading, two-ranked leaves and the more horizontal growth of branchlets of the bald cypress (Plate I).

The May 1948 collections were used for study of proembryo and early embryo stages, and the August 1947 collections provided material for matured seed and cotyledon counts. Megagametophytes containing proembryo stages were killed and fixed in F.A.A., sectioned ten microns in thickness and stained with Haidenhain's haemotoxylin and Orange G. Embryos in later stages were dissected and prepared according to the method used by Buchholz (1936). Terminology follows that of Buchholz (1946). The embryo pattern of development closely parallels that of *T. distichum* (Kaeiser, 1940).

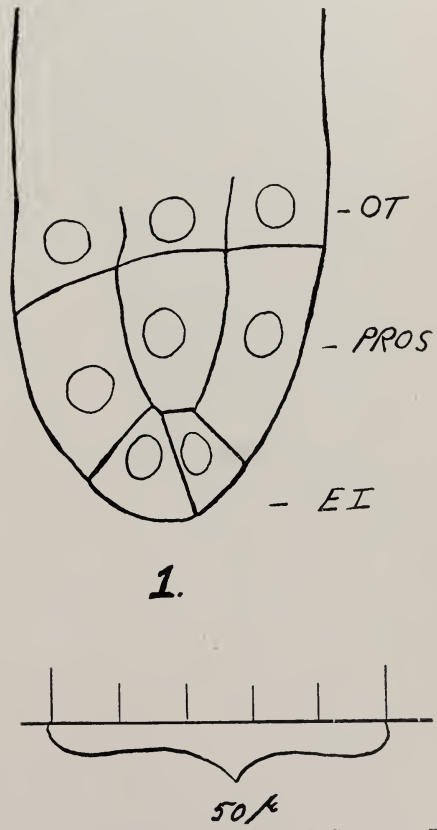

FIG. 1.—Proembryo of Pond Cypress, *T. ascendens*. OT, open tier of cells; PROS, prosuspensor; EI, embryo initials.

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PLATE I.—Left, Leaf and branchlet arrangement in *T. ascendens* Brongn. Right, Leaf and branchlet arrangement in *Taxodium distichum* (L.) Rich.

Proembryos were obtained of the stage shown in Figure 1. There is no rosette tier. The open tier (OT) has six cells. The prosuspensor tier (PROS) consists of six cells. At the bottom of the archegonium four embryo initials (EI) are present. The proembryo at this stage occupies approximately the lower one-third of the archegonium. The embryo initials are frequently arranged in tetrahedral fashion (Figs. 2, 2a, 2b). This organization is similar to that found in *T. distichum*. There is no primary suspensor system.

Of almost one hundred archegonial complexes examined which showed any subsequent development of embryos, the number of embryo systems of which each was developed from one proembryo ranged from one to four per archegonial complex. Most dissections revealed two or three separate embryo systems per archegonial complex. These resulted from separate fertilizations and are indicative of simple polyembryony.

The prosuspensor cells elongate and push through the lower portion of the archegonium. Some elongation is already apparent in Figure 1. They are often much coiled and twisted. Occasionally one or more may appear separated from the embryo initials (Fig. 2a). No other cell or cells appear to arise from these isolated prosuspensor cells.

The open tiers of nuclei, incompletely separated by walls, are transitory. Their nuclei had disintegrated in the later stages studied.

Figure 3 shows early divisions of the four embryo initials (EI) of one embryo system. Each unit is to be regarded as a separate embryo. This is an early indication of cleavage polyembryony.

Later stages in development of individual embryos appeared as shown in Figures 4-6. Figures 4 and 5 show the formation of embryonal tubes (ET). The embryonal tubes, formed by divisions of the embryo initials, form a secondary suspensor system.

Even in comparatively early stages of development of embryos from one embryo system, one of the embryos is usually larger in size, as shown in Figure 6. This figure shows only approximately one-third of the extensive prosuspensor.

In only one case of dissection of matured seeds was there found more than one embryo. (This would be indicative of simple polyembryony were it not for cleavage polyembryony which becomes manifest very soon.) In this case there was great discrepancy in size of the two embryos present within the megagametophyte and both appeared to be attached to the same prosuspensor system. In archegonial complexes examined that contained the sixteen-celled proembryos within the archegonia, it was noted that elongation of some of the prosuspensors was more advanced in some embryo systems than in others within the same complex. Embryo initials of some more advanced systems were also found to be more deeply imbedded in the gametophyte than were their neighbors from adjacent archegonia because of the greater elongation of their prosuspensors. These observations would suggest that the early rapid growth (elongation) of the prosuspensor cells of any one embryo system, as well as the earlier pre-

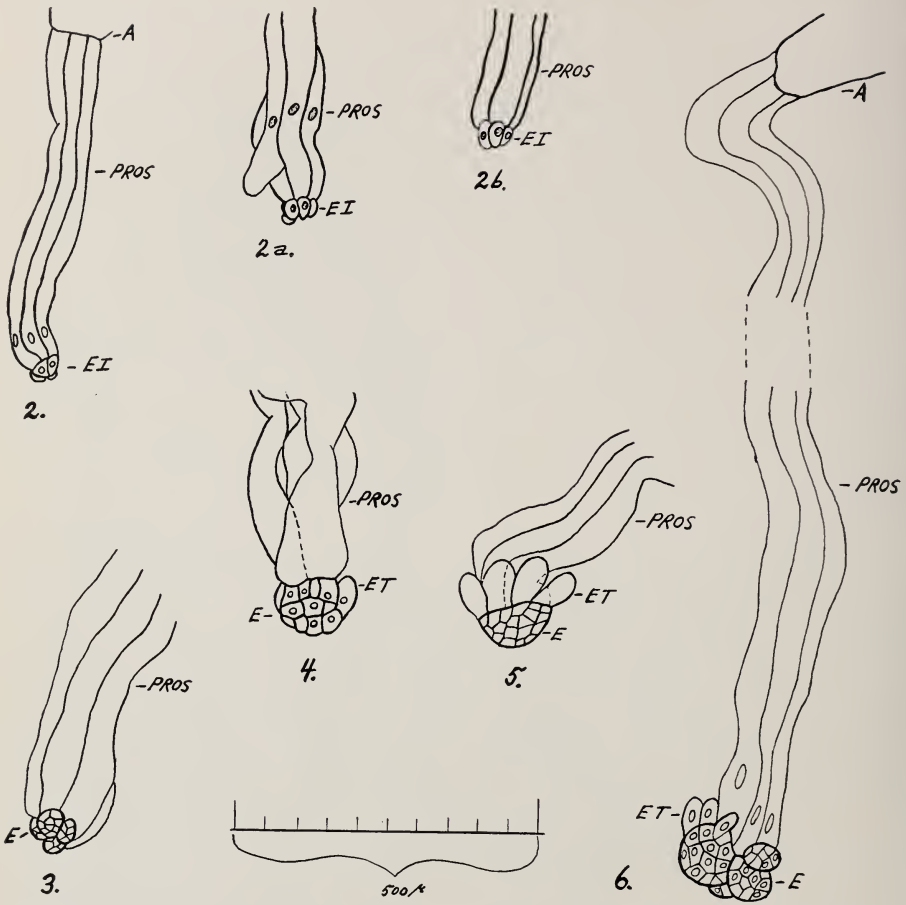

Fig. 2.—One embryo system showing elongated prosuspensor. A, archegonium; PROS, prosuspensor; EI, four embryo initials.

Fig. 2a.—Lower portion of one embryo system showing one of four prosuspensor (PROS) cells detached from embryo initials (EI).

Fig. 2b.—Lower portion of one embryo system showing three of four prosuspensor (PROS) cells and characteristic tetrahedral arrangement of embryo initial cells (EI).

Fig. 3.—Lower portion of one embyro system showing four prosuspensor cells (PROS) and four individual embryos (E). Early indication of cleavage polyembryony.

Fig. 4.—Later stage of embryo development (E) showing one embryonal tube (ET) of secondary suspensor system. PROS, prosuspensor.

Fig. 5.—Similar to Fig. 4, with additional embryonal tubes. PROS, prosuspensor; ET, embryonal tubes; E, embryo.

Fig. 6.—Approximately one-third of elongated prosuspensor shown. Note larger size of one embryo showing early stage in development of secondary suspensor system (ET). A, archegonium; PROS, prosuspensor; ET, one of several embryonal tubes attached to largest embryo; E, one of four embryos.

dominance in size of one of its embryos, are among the critical factors in determining which embryo shall ultimately survive.

The matured embryo closely resembles that of *T. distichum*.

Of five hundred seeds of *T. ascendens* selected at random from cones collected in August 1948, only 8.4 percent contained embryos. Of these matured embryos examined the number of cotyledons per embryo varied from five to seven with 69.04 percent showing six. Similar counts made of *T. distichum* (Kaeiser, 1940) from Arkansas yielded 16.6 percent good seeds, although 45 percent has been reported by R. M. Fisher of the Thompson Tree Nursery of Jonesboro, Illinois, for crops previous to 1939 in southern Illinois.* The cotyledon counts made by the author on three hundred *T. distichum* seedlings showed a range of four to eight with the majority showing six. The low percentage of pond cypress seeds with embryos might possibly be explained on an environmental basis. In the regions where collections were made the plants are referred to as "scrub cypress" and are of generally smaller growth than *T. distichum* (Davis, 1943).

* Personal correspondence.

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CHECK LIST OF THE VASCULAR PLANTS OF WINNEBAGO COUNTY, ILLINOIS

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Winnebago County is in the center of the northern boundary of the State of Illinois. It is traversed by the Rock River and two of its principal tributaries—the Kishwaukee and the Pecatonica—and Sugar River, a tributary of the Pecatonica, flows into the county from Wisconsin. Most of the county has moderate topography, the elevation ranging from 680 to 990 feet above sea level. The northwest corner is more hilly than the rest of the area.

Most of the county is covered by glacial drift which was deposited by the ice-sheet of the Illinoian glacial period. The Wisconsin ice-sheet, with its border to the north and east, contributed extensive terraces of glacial outwash gravel which filled the major stream valleys, in some places to a depth of more than 250 feet. The Belvidere lobe of the Early Wisconsin glaciation extended into the southeast corner of the county, cutting off the former valley of the Kishwaukee River and causing the stream to flow along the north edge of the glacier where it eroded a gorge in the bedrock about a hundred feet deep and several miles long. The lobe of ice also blocked the Rock River and caused it to form a new channel to the west of its former one, seen at Byron in Ogle County. Here, too, a gorge was cut into the bedrock, but not so clearly defined as along the Kishwaukee.

There are small outcrops of bedrock at a number of other widely scattered places in the county where streams have eroded new channels through the glacial drift. Some of the hilltops, especially in the west part of the area, are devoid of glacial drift and have rock directly beneath the soil. All of these outcrops are Galena dolomite except a small exposure of St. Peter sandstone on the east bank of Sugar River. The area bounded by the Sugar, Pecatonica, and Rock rivers consists largely of sandy soil and dune sand. The geography and geology of the county have been described in detail by various authors of the Illinois Geological Survey (2, 10, 11).

Like most of Illinois, in Winnebago County the vegetation consisted of a mixture of prairie and deciduous forest. The forest vegetation was mostly concentrated above the Pecatonica River and along the south and east boundaries of the county. The central area was largely prairie. The soil survey (6) shows accurately the limits of the soils formed under prairie and forest conditions.

The plant associations and habitats may be divided roughly into the following groups: forest, of which at least one area is predominantly sugar maple, others which were largely oak; prairie, ranging from low wet areas to dry hills; bogs, mainly sedge, but with several Sphagnum areas; swamps, especially along the Pecatonica River; streams; limestone outcrops; and sand. A num-

ber of unusual northern species of plants can be found in the bog and rock outcrop areas.

Agriculturally, the county is on the boundary between the corn belt and dairy country. Cultivation and grazing have profoundly modified the entire vegetation except for a very few small areas, yet there remains a remarkably diverse flora.

The flora of the county has been studied by many botanists, beginning with Michael S. Bebb (1). Gleason (5), in 1910, reported on the Sugar River sand area vegetation. The Nature Study Society of Rockford published lists of the woody plants of the area (8, 9). More recently Dr. Fernald, of Rockford College, has reviewed the work of former botanists (3) and published a list of the herbaceous plants (not including the ferns) of the county (4).

As a part of the Rockford Museum Project of the W. P. A., Dr. Fernald directed the collection of more than 1,000 plants in the county during the seasons of 1939 and 1940. These were deposited in the herbarium of Rockford College, duplicates being given to the Illinois State Herbarium at Springfield.

During the last few year intensive study of the flora has been made by the junior authors and the collections thus obtained have been deposited in the herbarium of the Illinois State Museum, Springfield, and on these specimens this list is based with a few exceptions that are in the herbarium of the Chicago Natural History Museum and these exceptions have been checked by the senior author. There are also a few that are in the herbarium of Rockford College which are marked with an asterisk (*) but have been reported in the previously published lists.

The taxonomic arrangement and nomenclature follow Jones (7) with very few exceptions.

Lycopodiaceae

Lycopodium lucidulum Michx.

Selaginellaceae

Selaginella rupestris (L.) Spring.

Equisetaceae

Equisetum arvense L.
" laevigatum A. Br.
" prealtum Raf.

Ophioglossaceae

Botrychium dissectum Spreng.
" multifidum (Gmel.) Rupr.
" obliquum Muhl.
" virginianum (L.) Sw.

Osmundaceae

Osmunda cinnamomea L.
" claytoniana L.
" regalis L.

Polypodiaceae

Cystopteris bulbifera (L.) Bernh.
" fragilis (L.) Bernh.
Onoclea sensibilis L.
Dryopteris cristata (L.) Gray
" intermedia (Muhl.) Gray
" spinulosa (Muell.) Watt
" thelypteris (L.) Gray
Polypodium virginianum L.
Camptosorus rhizophyllus (L.) Link
Asplenium platyneuron (L.) Oakes
Athyrium angustum (Willd.) Presl.
" thelypteroides (Michx.) Desv.
Cryptogramma stelleri (Gmell.) Prantl.
Pellaea glabella Mett.
Adiantum pedatum L.
Pteridium latiusculum (Desv.) Hieron.

Taxaceae

Taxus canadensis Marsh.

Pinaceae

Pinus strobus L.
Juniperus virginiana L.

Typhaceae

Typha angustifolia L.
" latifolia L.

Sparganiaceae

Sparganium americanum Nutt.
" eurycarpum Engelm.

Potamogetonaceae

Potamogeton americanus C. & S.
" foliosus Raf.
" lucens L.
" pectinatus L.

Alismaceae

Alisma subcordatum Raf.
Sagittaria brevirostra Mack & Bush
" latifolia Willd.
" longirostra (Micheli) Sm.*

Hydrocharitaceae
Anacharis canadensis (Michx.) Planch.
Gramineae
Bromus ciliatus L.
" commutatus Schrad.*
" inermis Leyss
" kalmii Gray
" secalinus L.
" tectorum L.
Festuca obtusa Spreng.
" octoflora Walt.
Glyceria grandis Wats.
" septentrionalis Hitchc.*
" striata (Lam.) Hitchc.
Poa annua L.
" compressa L.
" palustris L.*
" pratensis L.
" sylvestris Gray
Eragrostis capillaris (L.) Nees.
" cilianensis (All.) Link
" frankii C.A. Mey
" hypnoides (Lam.) BSP
" pectinacea (Michx.) Nees.
" spectabilis (Pursh) Steud.
Diarrhena americana Beauv.
Dactylis glomerata L.
Phragmites communis Trin.
Triodia flava (L.) Smyth
Agropyron repens (L.) Beauv.
" smithii Rydb.
Elymus canadensis L.
" villosus Muhl.
" virginicus L.
Hystrix patula Moench.
Hordeum jubatum L.
Koeleria cristata (L.) Pers.
Arrehnatherum elatius (L.) Mert. & Koch.
Danthonia spicata (L.) Beauv.
Calamagrostis canadensis (Michx.) Beauv.
Calamovilfa longifolia (Hook.) Scribn.
Agrostis alba L.
" hiemalis (Walt.) BSP.
Cinna arundinacea L.
Phleum pratense L.
Alopecurus carolinianus Walt.
Muhlenbergia foliosa (R. & S.) Trin.
" mexicana (L.) Trin.
" schreberi Gmel.
Sporobolus cryptandrus (Torr.) Gray
" heterolepis Gray
" neglectus Nash.
Orzopsis asperifolia Michx.
" racemosa (Sm.) Ricker
Stipa comata Trin. & Rupr.*
" spartea Trin.
Aristida oligantha Michx.
" purpurascens Poir.*
" tuberculosa Nutt.
Eleusine indica (L.) Gaertn.
Spartina pectinata Link
Bouteloua curtipendula (Michx.) Torr.
Hierochloe odorata (L.) Beauv.*
Leersia oryzoides (L.) Sw.
" virginica Willd.
Zizania aquatica L.
Digitaria ischaemum (Schreb.) Muhl.
" sanguinalis (L.) Scop
Panicum capillare L.
" clandestinum L.*
" dichotomum L.
" dichotomiflorum Michx.
" huachucae Ashe
" latifolium L.
" perlongum Nash.*
" scribnerianum Nash.
" villosissimum Nash.
" virgatum L.
Echinochloa crus-galli (L.) Beauv.
" walteri (Pursh) Heller
Setaria lutescens (Weigel) Hubb.
" viridis (L.) Beauv.
Cenchrus longispinus (Hack.) Fern.
Andropogon furcatus Muhl.
" scoparius Michx.
Sorghastrum nutans (L.) Nash.
Cyperaceae
Cyperus aristatus Rottb.
" diandrus L.
" engelmannii Steud.
" esculentus L.
" ferruginescens Boeckl.
" filiculmis Vahl.
" houghtonii Torr.
" rivularis Kunth.
" schweinitzii Torr.
" strigosus L.
Dulichium arundinaceum (L.) Britt.
Eleocharis acicularis (L.) R. & S.
" compressa Sulliv.
" engelmannii Steud.
" obtusa (Willd.) Schult.
" ovata (Roth.) R. & S.
" palustris (L.) R. & S.
" quadrangulata (Michx.) R. & S.
" tenuis (Willd.) Schult.
Bulbostylis capillaris (L.) Clarke
Hemicarpa micrantha (Vahl.) Britt
Fimbristylis autumnalis (L.) R. & S.
Scirpus americanus Pers.
" atrovirens Muh.
" cyperinus (L.) Kunth.
" fluviatilis (Torr.) Gray*
" lineatus Michx.
" validus Vahl.
Eriophorum angustifolium Honck.
" virginicum L.
Rhynchospora alba (L.) Vahl.
Scleria triglomerata Michx.
Carex aurea Nutt.
" bebbii Olney
" bicknellii Britt.
" blanda Dewey
" buxbaumii Wahl.
" cephaloidea Dewey
" cephalophora Muhl.
" chordorrhiza Ehrh.*
" comosa Boott.
" conoidea Schkuhr.
" cristatella Britt
" crus-corvi Shuttlew

Carex davisii Schw. & Torr.
" festucacea Schk.*
" filiformis L.
" gracillima Schw.
" granularis Muhl.
" gravida Bailey
" grisea Wahl.
" grayii Carey
" hirtifolia Mack.*
" hystricina Muhl.
" interior Bailey
" lanuginosa Michx.
" laxiflora Lam.
" longirostris Torr.
" lupulina Muhl.
" lurida Wahl.
" muskingumensis Schw.*
" muhlenbergii Schk.
" pennsylvanica L.
" plantaginea Lam.
" pseudo-cyperus L.
" retrorsa Schwein.*
" richardsonii R. Br.
" rostrata Stokes
" rosea Schk.
" scoparia Schk.
" shortiana Dewey
" sparganoides Muhl.*
" sprengelii Dewey
" stipata Muhl.
" straminea Willd.
" stricta Lam.
" tenera Dewey
" tribuloides Wahl.
" tuckermannii Dewey*
" varia Muhl.
" virescens Muhl.
" vulpinoidea Michx.

Araceae

Arisaema atrorubens (Ait.) Blume
" dracontium (L.) Schott.
Symplocarpus foetidus (L.) Nutt.
Acorus calamus L.

Lemnaceae

Lemna minor L.
" trisulca L.
Spirodela polyrhiza (L.) Schleiden

Xyridaceae

Xyris torta Sm.

Commelinaceae

Commelina communis L.
" virginica L.
Tradescantia canaliculata Raf.
" virginiana L.

Pontederiaceae

Pontederia cordata L.
Heteranthera dubia (Jacq.) MacM.

Juncaceae

Juncus acuminatus Michx.
" balticus var. littoralis Engelm.
" dudley Wieg.
" effusus L.
" greenei Oakes & Tuck.
Juncus interior Wieg.
" macer S. F. Gray
" marginatus Rostk.
" nodosus L.
" scirpoides Lam.
" vaseyi Engelm.
Luzula multiflora (Ehrh.) Lej.

Liliaceae

Hemerocallis fulva L.
Allium canadense L.
" cernuum Roth.
" tricoccum Ait.
Asparagus officinalis L.
Camassia scillioides (Raf.) Cory
Erythroniumllalbidum Nutt
" americanum Ker.
Lilium michiganense Farw.
" umbellatum Pursh
Maianthemum canadense var. interius Fern.
Ornithogalum umbellatum L.
Polygonatum biflorum (Walt.) Ell.
Uvularia grandiflora Sm.
Trillium gleasoni Fern.
" recurvatum Beck.
Smilacina racemosa (L.) Desf.
" stellata (L.) Desf.
Smilax ecirrhata (Engelm.) Wats.
" lasioneuron Hook.
" hispida Muhl.
" rotundifolia L.

Dioscoreaceae

Dioscorea villosa L.

Amaryllidaceae

Aletris farinosa L.
Hypoxis hirsuta (L.) Coville

Iridaceae

Belamcanda chinensis (L.) DC
Iris shrevei Small
Sisyrinchium albidum Raf.
" angustifolium Mill.
" graminoides Bickn.

Orchidaceae

Cypripedium candidum Muhl.
" parviflorum Salisb.
" reginae Walt.
Orchis spectabilis L.
Habenaria bracteata (Muhl.) R. Br.
" lacera (Michx.) Lodd.
" leucophaea (Nutt.) Gray
" psycodes (L.) Spreng.
Calopogon pulchellus (Salisb.) R. Br.
Triphora trianthophora (Sw.) Rydb.
Spiranthes cernua (L.) Rich.
Goodyera pubescens (Willd.) R. Br.
Liparis liliifolia (L.) Rich.
Aplectrum hyemale (Muhl.) Torr.
Corallorrhiza maculata Raf.

Salicaceae

Populus alba L.
" deltoides Marsh.
" grandidentata Michx.
" tremuloides Michx.

Salix amygdaloides Anders.
" bebbiana Sarg.
" candida Fluegge.
" cordata Muhl.
" discolor Muhl.
" fragilis L.
" glaucophylla Bebb.
" humilis Marsh.
" interior Rowlee
" lucida Muhl.
" nigra Marsh.
" pedicellaris Pursh.*
" petiolaris Sm.
" sericea Marsh.
" tristis Ait.

Juglandaceae
Juglans cinerea L.
" nigra L.
Carya cordiformis (Wang.) K. Koch.
" ovata (Mill.) K. Koch.

Betulaceae
Alnus incana (L.) Moench.
Corylus americana Walt.
Ostrya virginiana (Mill.) Koch.
Carpinus caroliniana Walt.
Betula lutea Michx. f.
" glandulifera (Regel) Butler
" pumila L.

Fagaceae
Quercus alba L.
" bicolor Willd.
" borealis Michx. f.
" ellipsoidalis Hill
" macrocarpa Michx.
" muhlenbergia Engelm.
" palustris Muench.
" velutina Lam.

Ulmaceae
Ulums americana L.
" fulva Michx.
Celtis occidentalis L.
Morus rubra L.

Cannabinaceae
Cannabis sativa L.
Humulus americanus Nutt.

Urticaceae
Urtica procera Muhl.
Boehmera cylindrica (L.) Sw.
Pilea pumila (L.) Grav
Laportea canadensis (L.) Gaud.
Parietaria pennsylvanica Muhl.

Santalaceae
Comandra umbellata (L.) Nutt.

Aristolochiaceae
Asarum acuminatum (Ashe) Bickn.
" reflexum Bickn.

Polygonaceae
Rumex acetosella L.
" altissimus Wood
" britannica L.
" crispus L.
" orbiculatus Gray
" verticillatus L.
Polygonum aviculare L.
" buxiforme Small
" coccineum Muhl.
" convolvulus L.
" hydropiper L.
" hydropiperoides Michx.
" lapathifolium L.
" orientale L.
" natans (Michx.) Eaton
" pennsylvanicum L.
" persicaria L.
" punctatum Ell.
" ramosissimum Michx.
" scandens L.
" sagittatum L.
" tenue Michx.
" virginianum L.
Polygonella articulata (L.) Meis.

Chenopodiaceae
Chenopodium album L.
" berlandieri Moq.*
" boscianum Moq.
" capitatum L.
" glaucum L.
" hybridum L.
" leptophyllum Nutt.*
" urbicum L.
Kochia scoparia (L.) Schrad.
Atriplex patula L.
Salsola pestifer A. Nels.

Amaranthaceae
Amaranthus blitoides Wats.
" graecizans L.
" hybridus L.
" retroflexus L.
" spinosus L.
Acnida altissima Riddell
" tamariscina (Nutt.) Wood.
Froelichia gracilis Moq.

Phytolaccaceae
Phytolacca americana L.

Nyctaginaceae
Mirabilis nyctaginea (Michx.) MacM.

Illecebraceae
Paronychia canadensis (L.) Wood
Scleranthus annuus L.

Aizoaceae
Mollugo verticillata L.

Portulacaceae
Talinum rugospermum Holz.
Claytonia virginica L.
Portulaca oleracea L.

Caryophyllaceae
Cerastium nutans Raf.
" vulgatum L.
Stellaria aquatica (L.) Scop.
" longifolia Muhl.
" media (L.) Cyril.
Arenaria lateriflora L.
" serpyllifolia L.
" stricta Michx.
Agrostemma githago L.

Silene antirrhina L.
" cucubalus Wibel.
" dichotoma Ehrh.
" nivea (Nutt.) Otth.
" noctiflora L.
" stellata (L.) Ait.
Lychnis alba Mill.
Saponaria officinalis L.
" vaccaria L.

Ranunculaceae
Caltha palustris L.
Hydrastis canadensis L.
Isopyrum biternatum (Raf.) T. & G.
Aquilegia canadensis L.
Actaea alba (L.) Mill.
" rubra (Ait.) Willd.
" rubra var. neglecta Gill.
Ranunculus abortivus L.
" acnis L.
" fascicularis Muhl.
" flabellaris Raf.
" hispidus Michx.
" pennsylvanicus L. f.
" recurvatus Poir.
" repens L.
" rhomboideus Goldie
" sceleratus L.
" septentrionalis Poir.
" trichophyllus Chaix.
Thalictrum dasycarpum F. & L.
" dioicum L.
" revolutum DC.
Anemone canadensis L.
" caroliniana Walt.
" cylindrica Gray
" ludoviciana Nutt.
" quinquefolia L.
" virginiana L.
Anemonella thalictroides (L.) Spach.
Hepatica acutiloba DC.
" americana (DC.) Ker.
Clematis virginiana L.

Nymphaeaceae
Nuphar advena Ait.
Nymphaea tuberosa Paine

Berberidaceae
Podophyllum peltatum L.
Jeffersonia diphylla (L.) Pers.
Caulophyllum thalictroides (L.) Michx.

Menispermaceae
Menispermum canadense L.

Lauraceae
Lindera benzoin (L.) Blume

Papaveraceae
Sanguinaria canadensis L.

Fumariaceae
Dicentra canadensis (Goldie) Walp.
" cucullaria (L.) Bernh.
Corydalis flavula (Raf.) DC.
" montana Engelm.
Fumaria officinalis L.

Cruciferae
Allaria officinalis Andrz.
Brassica alba (L.) Rabenh.
" arvensis (L.) Raben.
" campestris L.
" juncea (L.) Cosson
" nigra (L.) Koch.
Diplotaxis muralis (L.) DC.
Rorippa palustris (L.) Bess.
" sessiflora (Nutt.) Hitchc.
" sylvestris (L.) Besser
Sisymbrium altissimum L.
" officinale (L.) Scop.
Conringia orientalis (L.) Dum.
Erysimum cheiranthoides L.
" inconspicuum (Wats.) MacM.
Hesperis matronalis L.
Descurainia brachycarpa (Rich.) Schulz.
Draba reptans (Lam.) Fern.
Dentaria laciniata Muhl.
Iodanthus pinnatifidus (Michx.) Steud.
Cardamine bulbosa (Schreb.) BSP.
" douglassii (Torr.) Britt.
" pennsylvanica Muhl.
Arabis canadensis L.
" confinis Wats.
" dentata T. & G.
" laevigata (Muhl.) Poir.
" lyrata L.
" pycnocarpa Hopkins
Arabidopsis thaliana (L.) Heynh.
Nasturtium officinale R. Br.
Armoracia aquatica (Eaton) Greene
" rusticana Gaertn.
Berteroa incana (L.) DC.
Camelina microcarpa Andrz.
Lepidium campestre (L.) R. Br.
" perfoliatum L.
" virginicum L.
Thlaspi arvense L.
Capsella bursa-pastoria (L.) Medic.

Capparidaceae
Polanisia graveolens Raf.
" trachysperma T. & G.

Crassulaceae
Penthorum sedoides L.

Parnassiaceae
Parnassia glauca Raf.

Saxifragaceae
Heuchera hispida Pursh
Mitella diphylla L.
Sullivantia renifolia Rosend.
Saxifraga pennsylvanica L.
" virginiana Michx.

Grossulariaceae
Ribes americanum Mill.
" cynosbati L.
" missouriense Nutt.*
" odoratum Wendl.

Hamamelidaceae
Hamamelis virginiana L.

Platanaceae
Platanus occidentalis L.

Rosaceae
Physocarpus opulifolius (L.) Maxim.
Spiraea alba DuRoi
" tomentosa L.
Aruncus dioicus (Walt.) Fern.
Fragaria americana (Porter) Britt.
" virginiana Duch.
Potentilla anserina L.
" argentea L.
" arguta Pursh
" fruticosa L.
" monspeliensis L.
" palustris (L.) Scop.*
" recta L.
" simplex Michx.
Geum canadense Jacq.
" laciniatum Murr.
" strictum Ait.
" triflorum Pursh
Agrimonia gryposepala Wallr.
" parviflora Ait.
" pubescens Wallr.
" rostellata Wallr.
Rubus allegheniensis Porter
" flagellaris Willd.
" hispidus L.
" occidentalis L.
" pubescens Raf.
" strigosus Michx.
" spp.
Rosa blanda Ait.
" carolina L.
" palustris Marsh.
" suffulta Greene
Amelanchier arborea (Michx. f.) Fern.
" laevis Wieg.
" spicata (Lam.) K. Koch.
Pyrus communis L.
Malus ioensis (Wood) Britt.
Aronia melanocarpa (Michx.) Ell.
" prunifolia (Marsh.) Rehd.
Crataegus calpodendron (Ehrh.) Medic.
" locuples Sarg.
" mollis (T. & G.) Scheele
" pedicellata Sarg.
" pruinosa (Wendl.) K. Koch.
" punctata Jacq.
" succulenta Link
Prunus americana Marsh.
" lanata (Sudw.) M. & B.
" nigra L.
" pumila L.
" pennsylvanica L.
" serotina Ehrh.
" virginiana L.

Leguminosae
Desmanthus illinoensis (Michx.) MacM.
Gymnocladus dioica (L.) K. Koch.
Gleditsia triancanthos L.
Cassia fasciculata Michx.
" hebecarpa Fern.
Baptisia leucantha T. & G.
" leucophaea Nutt.
Lupinus perennis L.
Trifolium arvense L.
" hybridum L.
" pratense L.
" procumbens L.
" repens L.
Melilotus alba Desr.
" officinalis (L.) Lam.
Medicago lupulina L.
" sativa L.
Psoralea tenuiflora Pursh
Amorpha canescens Pursh
" fruticosa L.
Petalostemum candidum (Willd.) Michx.
" purpureum (Vent.) Rydb.
Tephrosia virginiana (L.) Pers.
Robinia pseudoacacia L.
Caragana arborescens Lam.
Astragalus canadensis L.
Desmodium canadense (L.) DC.
" canescens (L.) DC.
" dillenii Darl.
" glutinosum (Muhl.) Wood
" illinoense Gray
" nudiflorium (L.) D.C.
" paniculatum (L.) DC.
Lespedeza capitata Michx.
" hirta (L.) Horn.
" intermidia (Wats.) Britt.
" repens (L.) Bart.
" violacea (L.) Pers.
Vicia americana Muhl.
" caroliniana Walt.
" cracca L.*
" sativa L.
" villosa Roth.
Lathyrus myrtifolius Muhl.
" ochroleucus Hook.
" plaustris L.
" venosus Muh.
Apios americana Medic.
Strophostyles helvola (L.) Britt.
Amphicarpa bracteata (L.) Fern.
" comosa (L.) G. Don.

Geraniaceae
Geranium carolinianum L.
" maculatum L.
" sibiricum L.

Oxalidaceae
Oxalis corniculata L.
" cymosa Small
" stricta
" violacea L.

Linaceae
Linum sulcatum Riddell
" medium (Planch.) Britt.
" usitatissimum L.

Balsaminaceae
Impatiens biflora Walt.
" pallida Nutt.

Limnanthaceae
Floerkea proserpinacoides Willd.

Rutaceae
Zanthoxylum americanum Mill.
Ptelea trifoliata L.

Polygalaceae
Polygala cruciata L.
" incarnata L.
" polygama Walt.
" sanquinea L.
" senega L.
" verticillata L.

Euphorbiaceae
Acalypha virginica L.
Euphorbia commutata Engelm.
" corollata Pursh
" cyparissias L.
" esula L.
" geyeri Engelm.
" humistrata Engelm.*
" maculata L.
" marginata Pursh
" obtusata Pursh
" peplus L.
" polygonfolia L.
" supina Raf.
Poinsettia dentata (Michx.) Small
" heterophylla (L.) Small

Callitrichaceae
Callitriche heterophylla Pursh
" palustris L.

Celastraceae
Euonymus atropurpureus Jacq.
" obovatus Nutt.
Celastrus scandens L.

Aquifoliaceae
Ilex verticillata (L.) Gray

Anacardiaceae
Rhus aromatica Ait.
" arenaria (Greene) Jones
" glabra L.
" radicans L.
" typhina L.

Staphyleaceae
Staphylea trifolia L.

Aceraceae
Acer nigrum Michx. f.
" negundo L.
" rubrum L.
" saccharum Marsh.
" saccharinum L.

Rhamnaceae
Rhamnus cathartica L.
" frangula L.
" lanceolata Pursh
Ceanothus americanus L.
" ovatus Desf.

Vitaceae
Vitis aestivalis Michx.
" riparia Michx.
" vulpina L.
Parthenocissus quinquefolia (L.) Planch.

Tiliaceae
Tilia americana L.

Malvaceae
Malva rotundifolia L.
Callirhoe triangulata (Leav.) Gray
Napaea dioica L.
Sida spinosa L.
Abutilon theophrasti Medic.
Hibiscus trionum L.

Hypericaceae
Hypericum canadense L.
" ellipticum Hook.
" mutilum L.
" perforatum L.
" prolificum L.
" punctatum Lam.
" sphaerocarpum Michx.
Sarothra gentianoides L.
Triadenum virgincum (L.) Raf.

Cistaceae
Helianthemum canadense (L.) Michx.
" bicknellii Fern.
Lechea leggettii Britt. & Hollick
" stricta Legg.
" tenuifolia Michx.
" villosa Ell.

Violaceae
Viola canadensis L.
" conspersa Reich.
" cucullata Ait.
" eriocarpa Schw.
" fimbriatula Sm.
" lanceolata L.
" nephrophylla Greene
" pallens (Banks) Brain.
" papilionacea Pursh
" pedata L.
" pedatifida Don.
" pubescens Ait.
" sagittata Ait.
" striata Ait.
" sororia Willd.

Cactaceae
Opuntia rafinesquii Engelm.

Thymeleaceae
Dirca palustris L.

Lythraceae
Rotala ramosior (L.) Koehne
Ammania coccinea Rottb.
Decodon verticillatus (L.) Ell.*
Lythrum alatum Pursh
" salicaria L.

Onagraceae
Epilobium adenocaulon Hauss.
" augustifolium L.
" coloratum Muhl.
" leptophyllum Raf.
" strictum Muhl.
Ludwigia alternifolia L.
" palustris (L.) Ell.
" polycarpa S. & P.
Oenothera biennis L.
" laciniata Hill.
" pumila L.

Oenothera rhombipetala Nutt.
" speciosa Nutt.
Gaura biennis L.
Circaea latifolia Hill

Haloragidaceae

Myriophyllum heterophyllum Michx.
" verticillatum L.
Proserpinaca palustris L.

Cornaceae

Cornus alternifolia L. f.
" obliqua Raf.
" racemosa Lam.
" rugosa Lam.
" stolonifera Michx.

Araliaceae

Aralia nudicaulis L.
" racemosa L.
Panax quinquefolium L.

Umbelliferae

Eryngium yuccifolium Michx.
Daucus carota L.
Sanicula canadensis L.
" gregaria Bickn.
" marilandica L.
" trifoliata Bickn.
Osmorhiza claytoni (Michx.) Clark
" longistylis (Torr.) DC.
Cryptotaenia canadensis (L.) DC.
Chaerophyllum procumbens (L.) Crantz.
Zizia aptera (Gray) Fern.
" aurea (L.) Koch.
Taenidia integerrima (L.) Drude
Sium suave Walt.
Cicuta bulbifera L.
" maculata L.
Thaspium sylvaticum (Benke) Jones
" barbinode (Michx.) Nutt.
Polytaenia nuttallii DC.
Angelica atropurpurea L.
Heracleum lanatum Michx.
Pastinaca sativa L.
Coniosclinum chinense (L.) BSP.
Oxypolis rigidor (L.) Raf.
Carum carvi L.

Ericaceae

Chimaphila corymbosa Pursh
Pyrola elliptica Nutt.
" secunda L.
Monotropa uniflora L.
Gaylussacia baccata (Wang.) K. Koch.
Arctostaphylos uva-ursi (L.) Spreng.
Vaccinium angustifolium Ait.
" canadense Richards
" corymbosum L.

Primulaceae

Androsace occidentalis Pursh
Trientalis borealis Raf.
Lysimachia ciliata L.
" lanceolata Walt.
" nummularia L.
" quadriflora Sims.
" quadrifolia L.
" terrestris (L.) BSP.
Lysimachia thyrsiflora L.
" vulgaris L.
Dodecatheon meadia L.

Oleaceae

Fraxinus americana L.
" lanceolata Borkh.
" nigra Marsh.
" pennsylvanica Marsh.
" quadrangulata Michx.

Gentianaceae

Gentiana andrewsii Griseb.
" crinita Froel.
" flavida Gray
" procera Holm.
" puberula Michx.
" quinquefolia L.
" saponaria L.
Bartonia virginica (L.) BSP.
Nymphoides peltatum (Gmel.) Britten & Rendle

Apocynaceae

Apocynum androsaemifolium L.
" cannabinum L.
" pubescens R. Br.
" sibericum Jacq.*

Asclepiadaceae

Asclepias amplexicaulis Sm.
" incarnata L.
" phytolaccoides Pursh
" purpurascens L.
" pulchra Ehrh.
" quadrifolia Jacq.
" sullivantii Engelm.
" syriaca L.
" tuberosa L.
" verticillata L.
Acerates hirtella Pennell.
" languinosa Nutt.
" viridiflora (Raf.) Eaton*

Convolvulaceae

Convolullus arvensis L.
" sepium L.
" spithamaeus L.
Cuscuta glomerata Choisy
" gronovii Willd.
" spp.
Ipomoea purpurea (L.) Roth.

Polemoniaceae

Phlox bifida Beck.
" divaricata L.
" glaberrima L.
" pilosa L.
Collomia linearis Nutt.
Polemoniam reptans L.

Hydrophyllaceae

Hydrophyllum appendiculatum Michx.
" virginianum L.
Ellisia nyctelea L.

Boraginaceae

Cynoglossum officinale L.
Lappula echinata Gilib.
" virginiana (L.) Greene

Mertensia virginica (L.) Link
Myosotis arvensis (L.) Hill
" scorpioides L.
" verna Nutt.
Lithospermum angustifolium Michx.
" arvense L.
" canescens (Michx.) Lehm.
" croceum Fern.
" latifolium Michx.
Onosmodium hispidissimum Mack.
" occidentale Mack.

Verbenaceae

Verbena bracteata Lag. & Rodr.
" hastata L.
" simplex Lehm.
" stricta Vent.
" urticaefolia L.
Phyla lanceolata (Michx.) Greene

Labiatae

Teucrium canadense L.
" occidentale Gray
Isanthus brachiatus (L.) BSP.
Scutellaria ambigua Nutt.
" epilobiifolia Hamilt.
" lateriflora L.
" ovata Hill
" parvula Michx.
Marrubium vulgare L.
Agastache nepetoides (L.) Ktze.
" scrophulariaefolia (Willd.) Ktze.
Nepeta cataria L.
Physotegia speciosa Sweet
Physostegia virginiana (L.) Benth.
Glecoma hederacea L.
Prunella vulgaris L.
Leonurus cardiaca L.
Stachys arenicola Britt.
" aspera Michx.
" cordata Ridd.
" germanica L.
" homotrichia (Fern.) Rydb.
" tenuifolia Willd.
Salvia reflexa Hornem.
Blephilia ciliata (L.) Raf.
" hirsuta (Pursh) Torr.
Monarda fistulosa L.
" fistulosa f. alba
" punctata L.
Hedeoma hispida Pursh
" pulegioides (L.) Pers.
Pycnanthemum flexuosum (Walt.) BSP.
" pilosum Nutt.
" virginianum (L.) D. & J.
Lycopus americanus Muhl.
" rubellus Moench.
" uniflorus Michx.
" virginicus L.
Mentha canadensis L.
" citrata Ehrh.
" gentilis L. Glabrior (Hook) Rydb.
" piperita L.
" spicata L.

Solanaceae

Solanum carolinense L.
" dulcamara L.
Solanum nigrum L.
" rostratum Dunal
Physalis heterophylla Nees.
" lanceolata Michx.
" pubescens L.
" subglabrata M. & B.
" virginiana Mill.
Lycium halimifolia Mill.
Datura stramonium L.

Scrophulariaceaeae

Verbascum blattaria L.
" thapsus L.
Chelone glabra L.
Penstemon hirsutus (L.) Willd.
" digitalis Nutt.
" pallidus Small
Collinsia verna Nutt.
Scrophularia lanceolata Pursh
" marilandica L.
Linaria canadensis (L.) Dum.-Cours.
" minor (L.) Desf.
" vulgaris Mill.
Lindernia dubia (L.) Pennell
Gratiola neglecta Torr.
Leucospora multifida (Michx.) Nutt.
Mimulus ringens L.
Veronicastrum virginicum (L.) Farw.
Veronica americana (Raf.) Schw.
" arvensis L.
" connata Raf.
" peregrina L.
" serpyllifolia L.
Synthyris bullii (Eaton) Hell.
Aureolaria flava (L.) Farw.
" grandiflora (Benth.) Pennell
" pedicularia (L.) Raf.
Gerardia asper Dougl.
" gattingeri Small
" purpurea L.
" tenuifolia Vahl.
Dasistoma macrophylla (Nutt.) Raf.
Castilleja coccinea (L.) Spreng.
" sessiflora Pursh
Pedicularis canadensis L.
" lanceolata Michx.

Lentibulariaceae

Utricularis vulgaris L.

Orobanchaceae

Orobanche uniflora L.

Phrymaceae

Phryma leptostachya L.

Acanthaceae

Dianthera americana L.
Ruellia ciliosa Pursh

Plantaginaceae

Plantago aristata Michx.
" lanceolata L.
" major L.*
" purshii R. & S.
" rugelii Dcne.

Rubiaceae

Houstonia lanceolata (Poir.) Britt.
Cephalanthus occidentalis 1.
Diodia teres Walt.

Mitchella repens L.
Galium aparine L.
" asprellum Michx.
" boreale L.
" circaezans Michx.
" concinnum T. & G.
" obtusum Bigel.
" tinctorium L.
" trifidum L.
" triflorum Michx.

Caprifoliaceae

Sambucus canadensis L.
" pubens Michx.
Viburnum acerifolium L.
" affine Bush.
" lentago L.
" prunifolium L.
" rafinesquianum Schult.
" trilobum Marsh.
Symphoricarpos occidentalis Hook.
" rivularis Suksd.
Lonicera dioica L.
" flava Sims.
" prolifera (Kirsch.) Rehd.
Diervilla lonicera Mill.
Triosteum aurantiacum Bickn.
" perfoliatum L.

Valerianaceae

Valeriana ciliata T. & G.

Cucubitaceae

Echinocystis lobata (Michx.) T. & G.
Cucurbita foetidissima HBK.
Sicyos angulatus L.

Campanulaceae

Campanula americana L.
" aparinoides Pursh.
" rotundifolium L.
" uliginosa Rydb.
Specularia perfoliata (L.) A. DC.

Lobeliaceae

Lobelia cardinalis L.
" inflata L.
" kalmii L.
" siphilitica L.
" spicata Lam.

Compositae

Iva ciliata Willd.
" xanthifolia Nutt.
Ambrosia coronopifolia T. & G.
" elatior L.
" trifida L.
Xanthium commune Britt.
Vernonia fasiculata Michx.
Eupatorium altissimum L.
" maculatum L.
" perfoliatum L.
" purpureum L.
" rugosum Houtt.
" serotinum Michx.
Kuhnia eupatorioides L.
Liatris aspera Michx.
" bebbiana Rydb.
" cylindracea Michx.
" spicata (L.) Willd.
Grindelia squarrosa (Pursh) Dunal
Solidago altissima L.
" canadensis L.
" glaberrima Martens
" hirtella (Greene) Bush
" juncea Ait
" latifolia L.
" media (Greene) Bush
" nemoralis Ait.
" riddellii Frank
" rigida L.
" serotina Ait.
" speciosa Nutt.
" ulmifolia Muhl.
" uliginosa Nutt.
Boltonia asteriodes (L.) L'Her.
Aster anomalus Engelm.
" azurus Lindl.
" cordifolius L.
" drummondii Lindl.
" dumosus L.
" ericoides L.
" junceus Ait.
" laevis L.
" lateriflorus (L.) Britt.
" linariifolius L.
" novae-angliae L.
" oblongifolius Nutt.
" paniculatus Lam.
" pilosus Willd.
" prealtus Poir.
" prenanthoides Muhl.
" ptarmicoides (Nees.) T. & G.
" sagittifolius Wed.
" sericeus Vent.
" shortii Lindl.
" umbellatus Mill.
" vimineus Lam.*
Erigeron annuus (L.) Pers.
" canadensis L.
" divaricatus Michx.*
" philadelphicus L.
" pulchellus Michx.
" strigosus Muhl.
Antennaria fallax Greene
" neglecta Greene
" neodioica Greene
" plantaginifolia Hook.
Gnaphalium obusifolium L.
Polymnia canadensis L.
Silphium integrifolium Michx.
" laciniatum L.
" perfoliatum L.
" terebinthinaceum Jacq.
Parthenium integrifolium L.
Heliopsis helianthoides (L.) Sweet
Rudbeckia hirta L.
" laciniata L.
" subtomentosa Pursh
" triloba L.
Brauneria pallida (Nutt.) Britt.
" purpurea (DC.) Britt.
Ratibida pinnata (Raf.) Blake
" columnifera (Nutt.) W. & S.
Galinsoga ciliata (Raf.) Blake

Helianthus annuus L.
" decapetalus L.
" divaricatus L.
" giganteus L.
" grosseserratus Martens
" hirsutus Raf. L Mollis Lam.
" occidentalis Riddell
" petiolaris Nutt.
" rigidus (Cass.) Desf.
" strumosus L.
" tuberosus L.
Coreopsis lanceolata L.
" palmata Nutt.
Bidens aristosa (Michx.) Britt.
" comosa (Gray) Wieg.
" connata Muhl.
" coronata (L.) Britt.
" frondosa L.
" laevis (L.) BSP.
Helenium autumnale L.
Achillea millefolium L.
Chrysanthemum leucanthemum L.
Anthemis cotula L.
" tinctoria L.
Tanacetum vulgare L.
Artemisia annua L.
" biennis Willd.
" caudata Michx.
" dracunculoides Pursh
" gnaphaloides Nutt.
" serrata Nutt.
Cacalia atriplicifolia L.
" muhlenbergii (Sch-Bip.) Fern.
" suaveolens L.
" tuberosa Nutt.
Erechtites hieracifolia (L.) Raf.
Senecio arueus L.
" pauperculus Michx.
" plattensis Nutt.
Arctium minus (Hill) Bern.
Cirsium altissimum (L.) Spreng.
" arvense (L.) Scop.
" dicolor (Muhl.) Spreng.
" hillii (Canby) Fern.
" muticum Michx.
" vulgare (Savi) Airy-Shaw
Centaurea cyanus L.
" maculosa Lam.
" nigra L.
Tragopogon pratensis L.
Krigia biflora (Walt.) Blake
" virginica (L.) Willd.
Cichorium intybus L.
Lactuca canadensis L.
" biennis (Moench) Fern.
" floridana (L.) Gaertn.
" pulchella (Pursh) DC.
" sagittifolia Ell.
" scariola L.
Sonchus arvensis L.
" asper (L.) Hill
" oleraceus L.
Prenanthes alba L.
" altissima L.
" aspera Michx.
" cripidinea Michx.
" racemosa Michx.
Hieracium aurantiacum L.*
" canadense Michx.
" gronovii L.
" longipilum Torr.
" scabrum Michx.
Agoseris cuspidata (Pursh) D. Dietr.
Taraxacum vulgare (Lam.) Schrank
" laevigatum (Willd.) DC.

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CHEMISTRY

PLACE OF SCIENCE IN GENERAL EDUCATION

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The emergence of the United States as a leading world power and the obvious lack of preparation on the part of our citizens and leaders for their widened responsibilities has resulted in the realization of a need for a common grasp and a common over-view in the handling of facts and ideas in many discrete and isolated fields of knowledge. This great need has been met by educators through general education. The term has many and vigorous antagonists, especially in the science field, mainly because of a misconception and a misunderstanding of its fundamental meaning. Defined very simply, general education is non-vocational; it is that education which is the antithesis of a specialized education. However, general education is really a philosophy of education, and consequently has shades of meaning and application that are not so simply defined. In the East, the problem has been studied as "integrated" education, a term probably more readily acceptable to faculty members. There, general education is considered as only one phase of the broader integrated education because general education is concerned with giving all students, regardless of the later area of specialization, a basic understanding of the sciences, social sciences, and the humanities, culminating in integrated knowledge.

Whether we call it general or integrated education, the educators in the scientific world have been challenged: first, to devise suitable means of educating the layman, enabling him to have a better knowledge of science, a better understanding of its philosophy and methods, and a deeper appreciation of its potentialities and its limitations; second, to supplement the efforts of the social scientists and the teachers in the humanities in the attainment of the common goals of integrated understanding and appreciation. Whether or not this challenge be recognized or accepted depends on the open-mindedness and honesty of the scientists, and the rigorous, ruthless, and patient intellectual grasp of the many difficulties contingent on that challenge. During the past several years many scientists have expressed their opinions on this educational problem. Dr. Anton Carlson of the University of Chicago stated:

> If it be true that an understanding of the scientific method and the fundamentals of the nature of man and the nature of the universe already achieved by the natural sciences is significant in a liberal college education, it would seem timely that we of the college faculties study this problem again, for I am satisfied that our nondescript "science requirement" for graduation usually falls short of the above goal. Streamlining the natural sciences in the college in the direction of purely vocational and professional training will not bring that goal even within sight of the mine run

of college students. . . . We of the faculties must re-evaluate and reconstruct our entire college curriculum in the directions of essentials and mastery, and not primarily in the direction of speed, technical trades and professions, no matter how strong the myopic drive in the latter direction may grow. If we could discover the essential core of liberal education, then mastery, rather than speed would seem to be the goal.[1]

Along the same line, Dr. James R. Kilian, Jr., the President of Massachusetts Institute of Technology, recently stated the need for a broader general education for science students:

> Engineers, scientists, physicians and other professional men are often called upon to assume important positions of leadership in the community. Unless they are aware of the major issues of the world, they may find it difficult to give competent direction. . . . Colleges have a profound responsibility to develop men and women who are not only skilled technicians but alert, intelligent citizens.[2]

Dr. Kilian explained that the objective of MIT is to educate top-flight engineers, scientists, and architects who may become community leaders. When technical education is too narrow, it tends to restrict the development of leaders. He insists that professional schools everywhere place greater emphasis on the teaching of humanities. Twenty percent of the total curriculum of the scientist at MIT runs to humanities, and he belives that in the years to come there will be a substantial increase.

There has always appeared to be a dichotomous viewpoint on science. Some scientists have exaggerated the need and importance of their subject matter to such an extent that their schools are turning out brilliant physicists and chemists with little background in cultural education or a vital preparation for living in a world of immediate social and economic problems. They use the scientific method in their field unfailingly and blindly but seem to be incapable of making the transfer of training to their problems of life. As Professor Phillip Frank of Harvard stated in the *American Journal of Physics,*

> The result of conventional science teaching has not been a critically minded type of scientist but just the opposite. . . . This failure prevents the science graduate from playing in our cultural and public life the great part that is assigned to him by the ever mounting technical importance of science to human society.[3]

To such scientists, science is the *end-all* of education.

The other viewpoint on science teaching is that taken by many professors of the social sciences and the humanities, and by many scientific workers themselves. They look on science as a mere tool, a useful servant of humanity and forget that it is an integral part of human knowledge. They confound science with technology. Science aims at a systematic understanding of the world, while technology aims at the construction of consumers' goods on the basis of such theoretical understanding.

Fundamentally, the problem seems to be to influence all members of the faculty to appreciate the importance of each discipline and to so integrate the subject matter that the foundation of each liberal arts student be soundly based on all the broad areas of learning. The common criticism, as exemplified in the

[1] Carlson, Anton J., "The Offerings and Facilities in the Natural Sciences in the Liberal Arts Colleges," *North Central Association Quarterly,* XVIII, No. 2. (October, 1943), 154.

[2] Education in Review, *New York Times,* March 27, 1949.

[3] Frank, Phillip, *American Journal of Physics,* XV (1947), 202.

statements of the men quoted above, has often been that the scientist has over-loaded his curriculum to a much greater and more obvious extent than the social scientist and the student in humanities. However, just as educators will insist (and rightly) that a scientist is not liberally educated unless he has a good background in history and socio-economic problems, so, too, no one who is ignorant of science in nearly all of its aspects can be considered an educated person.

Dr. Van Evera of George Washington University recently discussed the position of chemistry in our present-day liberal arts education. He admits that the so-called liberal arts college no longer gives a liberal arts degree but rather a series of junior professional degrees and thus we do not truly have liberal education in the original sense of a hundred years ago, which was that education turned out men who used beautiful English naturally, who had a great breadth of knowledge, and who were quite practical in their approach to the problems of life. However, Dr. Van Evera states that the chemistry major's curriculum of today with its requirements in history, sociology, economics, and English, is nearly as broad and fundamental as was that of the liberal arts student a hundred years ago. And thus he claims that the science major is a far more broadly trained man than is his classmate who has almost no science. This statement depends, of course, on the requirements of each chemistry department for work in other fields versus the requirements in science for the non-science majors.[4]

[4] Van Evera, Benjamin D., "Chemistry and Liberal Education," *Chemical and Engineering News*, XXVI, No. 7 (February 16, 1948), 446.

Consequently, as a result of these divergent viewpoints on the present status of science in the liberal arts college, the two-pronged challenge thrown to the scientists must be accepted and studied. It is a problem that deserves immediate action, not one to be cast aside as the mere bickering of educationists.

The first challenge was to plan courses for an integrated general education program that will enable the non-science major to obtain a better knowledge of science, a better understanding of its philosophy and methods, and a deeper appreciation of its potentialities and its limitations. Does the system of elementary single-science courses given alike for majors and non-majors meet this demand? This question can be answered only in the light of the objectives of the course related to the general education of the student. Much discussion in regional work-shops and in national conferences has centered around this question, with the consequent development of basic general courses, scholarly in character but selective in content, involving the integration of several sciences and based on the purpose of acquisition of certain broad aims.

There is still a great deal of confusion surrounding the question of the proper content of a general course in science. A survey of what has been done along these lines has been edited by McGrath in *Science in General Education*.[5] Twenty-one representative colleges and universities have cooperated in the study and much valuable information is here available. No matter how many

[5] McGrath, Earl J., Editor, *Science in General Education*, Wm. C. Brown Co., Dubuque, Iowa, 1948.

and how varied the plans are that are studied the one criterion which is used in building a general course is: How much does the teacher have to give? Each general course is individual and unique in method of approach, selection of material, the organization of the material and emphasis. The only underlying common denominator is the end and objective of the general course, which is concisely stated in the fourth objective quoted by the President's Commission on Higher Education: To understand the common phenomena in one's physical environment, to apply habits of scientific thought to both personal and civic problems, and to appreciate the implications of scientific discoveries for human welfare.

Besides elementary science general courses, other science courses should be devised to be offered as electives to non-science majors, upper classmen, so they can broaden their general background in science. These should not be laboratory courses, for a non-science major will not elect a subject that will take a considerable amount of time. He is interested in fundamental knowledge, not in techniques. We science teachers often offer the observation that our majors must be generally educated since they frequently elect subjects outside their field in their junior and senior years, and that the non-science majors seldom, if ever, elect anything in science to balance their general education. Though this is true, the fault probably lies with us. We do not offer two and three hour courses in science with little or no prerequisites that any liberal arts student is invited to elect. Most of our science courses, if elementary, have long hours of laboratory work, and otherwise have heavy prerequisites.

Now to the second part of the challenge thrown to the scientists: along with the faculties in the other areas, they are to integrate subject matter into one whole, so that the student realizes his common goal of understanding and appreciation. This is a plea to cut across departmental lines in order to unify learning, to build not only vertically through the subject matter structure of the course but to spread horizontally, reaching out for implications in other and allied fields, linking together science with social science, with the humanities, with language, and with communications. General education courses are intended to impart a broad point of view, looking at the subject matter in its relation to the whole range of man's practical and intellectual interests and as part of the essential background against which the problems of contemporary civilization must find their solution. The suggestion has been offered that the general education of the science major be broadened by means of a course given in the senior year which would integrate related sciences and also show their relationship to non-science fields. Such a course, it is obvious, requires a generally educated teacher, and it is thus inevitable that the course reflect the mind and personality of the teacher far more than the traditional purely departmental courses. The success of any of these general courses, the rigorousness with which they are handled, and the strict regard given to the prin-

ciples of exact, systematic inquiry, depend primarily and solely on the teacher. There is no reason, except in the individual teacher, why any general course should be accused of dragging down academic standards by being a "watered-down" course.

The many difficulties and advantages of such courses need to be analyzed by individual institutions in the light of the needs of their students, the qualities of their faculties, and the purposes or objectives of their curricula. Only in this way will the challenge which the modern world has thrown to education be met.

GEOGRAPHY

OCCUPANCE OF THE MISSISSIPPI BORDER OF SOUTHERN ILLINOIS

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The Terrain

About six miles below the Kaskaskie cutoff the Mississippi River abruptly swings from the left to the right side of its steep walled valley trough, and there it remains for the next fifty miles of its course. At this point the river is deflected sharply to the right to form the Cape Girardeau bend, below which it traverses a narrow six-mile channel through the hills to enter the broad alluvial plain below. This portion of the valley trough is the lower southern segment of the Mississippi border, one of the geographic sections of the southern district of Southern Illinois.

Physiographically, the southern district of Illinois is essentially that portion of the state south of the glacial boundary where the Ozark Plateau, the Interior Low Plateau, and the Coastal Plain provinces center. Geographically, the Mississippi border is a valley trough conspicuously incised in the eastern margin of the Salem Plateau. The Fountain Bluff bend is the only part of the trough eroded in the Shawnee Hills. The valley trough, which is here about six miles wide, describes a broad flat arc to the east. Since the river follows the right wall of the valley, which is the inside of the arc, the left or Illinois side of the valley is a broad alluvial bottom with a fall of about 0.4 foot per mile. Steep sided valley walls rising to a maximum of about 350 feet above the alluvial floor sharply delimit the segment.

The river itself, which varies in width from half a mile to 1¼ miles, is about 20 feet below the alluvial floor except at flood stage. Damaging floods occur in this segment of the valley about every seven years. The highest portion of the valley floor is the natural levee along the river upon which artificial levees have been constructed to protect the bottom lands from all but the most severe floods. From the natural levee the wide alluvial valley floor slopes gently toward the valley wall, forming swamps and poorly drained forested depressions adjacent to the steep valley wall. Drainage ditches have been constructed in an attempt to reclaim the poorly drained alluvial land for agriculture. Big Muddy River, the only tributary of any significance, enters the valley trough from the northeast, and pursues a meandering course through the lowland along the left valley wall for about 15 miles before entering the Mississippi through the Grand Tower chute. Although this is the widest part of the entire segment, Fountain Bluff, a forest covered remnant of the Shaw-

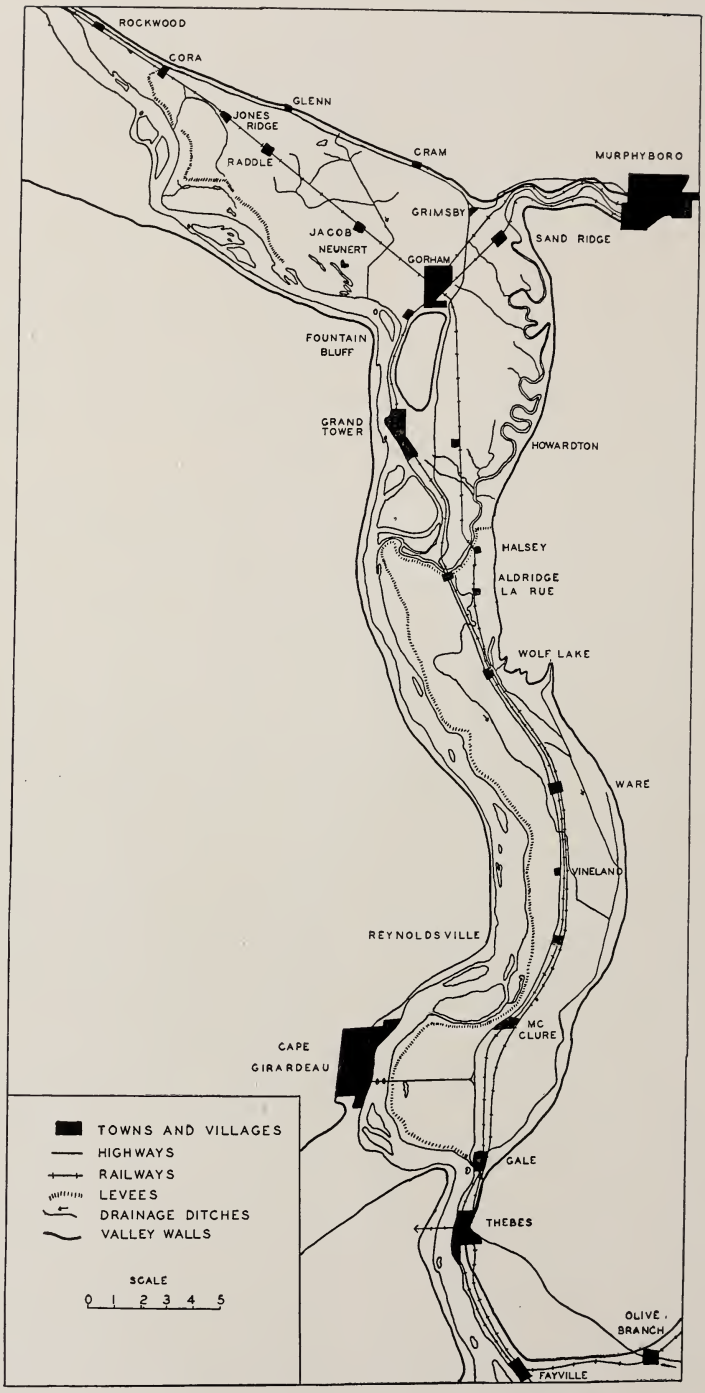
ROCKWOOD
CORA
GLENN
JONES RIDGE
RADDLE
CRAM
MURPHYBORO
GRIMSBY
JACOB
NEUNERT
SAND RIDGE
GORHAM
FOUNTAIN BLUFF
GRAND TOWER
HOWARDTON
HALSEY
ALDRIDGE
LA RUE
WOLF LAKE
WARE
VINELAND
REYNOLDSVILLE
MC CLURE
CAPE GIRARDEAU
GALE
THEBES
OLIVE BRANCH
FAYVILLE
TOWNS AND VILLAGES
HIGHWAYS
RAILWAYS
LEVEES
DRAINAGE DITCHES
VALLEY WALLS
SCALE
0 1 2 3 4 5

FIG. 1

nee Hills three miles long and 1½ miles wide, rises above the alluvial floor at the river's edge (fig. 1). Although physically similar throughout, Big Muddy River conveniently divides the segment at the point where it crosses the valley bottom. Above are the Fountain Bluff and Oakwood bottoms, whereas below the Big Muddy are the Union bottoms, Cape Girardeau bend, and the Thebes narrows.

Cultural Patterns

Although corridor-like in its physical qualities, this segment of the Mississippi border is primarily a commercial agrarian ribbon penetrating a subsistence hills land, and is secondarily a corridor.

Corridor Qualities

The corridor qualities of the southern segment of the Mississippi border are best exemplified by the nature of the several patterns of transportation that occupy the valley trough. Water, rail, and highway routes parallel one another up and down the valley essentially from East St. Louis to Cairo. Barge transportation of bulky non-perishable freight on the river is undoubtedly the outstanding corridor quality since it is a portion of a major national route. Water transportation is of no major significance to the segment itself, although there are numerous landings along the waterfront. The railroads and the highways are better prepared to serve the agrarian valley floor.

Of the several railroads that serve the valley only one, the Missouri Pacific, traverses the entire segment on its way from East St. Louis to Cairo. From one end of the other this railroad right-of-way occupies a well-graded mid-position on the wide valley bottom. The Illinois Central and a branch of the Missouri Pacific enter the valley trough through the valley of the Big Muddy (fig. 1). The Missouri Pacific joins directly with the valley route whereas the Illinois Central crosses the valley floor to the waterfront, traversing the narrow terrace between Fountain Bluff and the river through Grand Tower where the rail pattern makes contact with river navigation. Below the Big Muddy River the Illinois Central parallels the Missouri Pacific railroad down the center of the valley bottom to the narrows. There the Illinois Central follows the waterfront, whereas the Missouri Pacific describes two arcs through the hills, one above and one below Thebes, where they join in a Y and cross the Mississippi on the only railroad bridge in the entire segment. For the last three miles the Missouri Pacific follows the waterfront as does the Chicago and Eastern Illinois which comes in over the Illinois Central tracks from the south to make contact with the waterfront.

The major highways form a similar pattern, making use of the same physical feature. The major highway, State Route 3 from Cairo to East St. Louis, traverses the entire segment. South of the Big Muddy River the highway and the two railroads follow the same route up the center of the alluvial valley floor. North of the Big Muddy where the railroads separate, the highway continues on a straight course up the valley along the eastern edge of Fountain Bluff directly to the valley

wall which it follows for the rest of the distance. State Route 146 from Cape Girardeau, Missouri, to Murphysboro crosses the Mississippi on a toll bridge and joins State Route 3 which it follows to the mouth of the Big Muddy valley where it leaves the valley. Innumerable short unimproved roads, chiefly levee and trans-valley routes, complete the pattern of transportation.

Settlements

Within the segment are 20 towns and villages which vary in population from ten to 1,043. With the exception of two small villages all are on the railroad, indicating the commercial nature of the valley bottom agriculture. There are several railroad stations not connected with villages. Only four of the towns and villages are incorporated. Grand Tower with a population of 1,043 is the largest and Rockwood with only 246 is the smallest. Thebes, population 730 and the second largest town, like Grand Tower is a railroad town on the waterfront. Unlike Grand Tower, Thebes occupies the hills on the narrows at the lower end of the segment. Gorham, population 595, is a railroad junction. McClure, population 450, is the largest unincorporated village. The other fifteen villages are mere hamlets consisting only of the necessary function of a commercial agrarian area. Only three of this group have a population of 100 and more, and the largest, Gale, is only 200. Nine of the twenty towns and villages have post offices and only two, Grand Tower and Gorham, have banking facilities. One little hamlet, Neunert, with a population of 31, occupies a site on the valley floor untouched by railroad, hardsurfaced highway, or river transportation.

Agrarian Patterns

As the little market towns arranged at regular intervals along the railroads attest, commercial grain farming is the dominant economy of this segment of the Mississippi border. The deep alluvial soil of the valley floor is the basic natural environmental item upon which this type of productive occupance is based. Recent alluvium and the prairie soils of the recent Wisconsin drift are the only types of areas in Illinois capable of withstanding the drain of continuous commercial grain cropping. Thus the entire segment is one continuous ribbon of commercial grain farming, varying from place to place only in intensity and arrangement of details. Corn rotated with winter wheat constitute the basis of production, with alfalfa and other hay crops to feed the small livestock population a low second. Hogs are the most important animals although a few cows and work animals are kept on each farm. Although most of the farms are mechanized, heavy machinery is not used to the best advantage on poorly drained land. Especially on the smaller farms mules furnish most of the motive power. Much of the valley floor is poorly drained despite drainage ditches, leaving large tracts of tree lined swamps on the lowest portions of the valley floor.

Valley Bottom Sectors

North of Big Muddy River, which conveniently bisects the valley segment at the place where it enters

the Mississippi, are two valley bottom sectors. From Rockwood to the Fountain Bluff bend, which lies directly across the valley bottom from the mouth of the Bid Muddy valley, is the Fountain Bluff bottom. This sector of the valley bottom is approximately sixteen miles long and about six miles wide. Although a levee, some places as far as a mile from the river, encloses the upper half of the sector behind which drainage ditches carry water to the river, large tracts are swamps and marshes.

Approximately half of the bottom land is cultivated. Winter wheat and corn constitute the major crops and are about equal in acreage. The production per acre of both crops is highest here of any place in the valley. The acreage of wheat is a little greater than that of corn. Hay crops and oats form a weak second to corn and wheat and are used as forage for the livestock since much of the grain is sold. Much of the soil is heavy clay which is difficult to cultivate under unfavorable moisture conditions and thus accounts for much unused arable land.

Five small market towns spaced at approximately three mile intervals line the railroad in the center of the valley bottom whereas several more line the highway at the foot of the valley wall. Neunert is the center of a German farming community between the railroad and the river. Gorham or Fordyce at the railroad junction is the largest town in the sector.

From the Fountain Bluff bend to the mouth of the Big Muddy is the Oakwood bottom, a sector about twelve miles long and six miles wide. Because of the position of Fountain Bluff on the waterfront and the relatively high natural levee along the remainder, protecting levees have not been built except to enclose the Big Muddy River on the south. Since settlement is limited to the wide natural levee, the low bottom to the east, through which the Big Muddy meanders and into which the drainage of the sector is ditched, is allowed to flood in periods of danger to cities down-stream. Much of the sector, including Fountain Bluff but excluding the southeastern natural levee, is within the limits of the Shawnee National Forest.

Although less agricultural than any other sector, commercial grain farming of corn and winter wheat predominates in the cultivated portions of the valley bottom. Unlike the Fountain Bluff bottom to the north where wheat was slightly greater in acreage than corn, corn acreage exceeds wheat by about one-third. This is in part due to late floods and the necessity of replanting.

Small market towns are conspicuously absent. Grand Tower, the largest town in the entire valley segment, is an old river-town through which a railroad passes although the highway by-passes it about a mile to the east.

South of the Big Muddy River is the Union Bottom sector which extends for about eighteen miles down the valley where it joins the Cape Girardeau bend, the inside of a sharp four mile bend of the Mississippi. The entire area is enclosed by a levee from the valley bluff south of the Big Muddy to the valley bluff below the Cape Girardeau bend. Almost the entire sector is drained into

a main ditch which parallels the left valley wall on the lowest part of the valley bottom and enters the Mississippi through a small tributary stream at the point where the river approaches the left bluff below the Cape Girardeau bend.

Commercial grain farming dominates the flat alluvial land. Unfenced fields of corn and winter wheat with small areas of hay are characteristic. Hogs are the most important livestock. Small market villages spaced at about three mile intervals line the railroad and the highway which in this sector of the valley traverse the middle of the valley floor.

South of the Cape Girardeau bend the river enters the Thebes narrows, a valley less than three quarters of a mile wide which extends for about six miles through the hills to the broad embayment below. The railroads and highway from the wide alluvial bottom concentrate in the narrow valley, and at Thebes a high level railroad crossing is made at the narrowest point in the valley.

These are the essentials of the occupance of a segment of the Mississippi border. The homogeneous valley trough is the basis upon which the occupance is organized. Problems arising from unwise associations of cultural and natural environmental conditions are varied and conflicting. Commercial grain farming is the major association with the recent alluvial soil, but it has its attendant problems of drainage and flooding. The transportation factors are associated with the well graded and orientated corridor. These are local or at best interregional considerations. Flood control and other problems related directly to the river are intraregional in nature, the solution of which has very far-reaching ramifications.

Thus the southern segment of the Mississippi border is essentially a fifty mile ribbon of commercial grain farming as well as a corridor of secondary consideration associated with a wide alluvial valley bottom which is projected through the hills land of the southern district of Illinois.

THE PULP AND PAPER INDUSTRY OF THE LAKE STATES

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Four regions of the United States are outstanding in the production of paper: (1) the Northeast; (2) the Pacific Northwest; (3) the South; and (4) the Lake States. Paper making in the first of the regions, the Northeast, dates back to 1690.[1] For more than a century the Northeast held a virtual monopoly on American paper manufacturing. Three important factors influenced the location of the industry during that early period: (1) cheap power; (2) a large volume of clear and pure process water; and (3) proximity to large centers of population.[2] The migration of the paper industry into the other three regions had to await economic developments in those regions and technological developments in the industry.

In the Lake States[3] the earliest beginnings of the paper industry appeared around 1800. Development in this region was assisted by four forces: (1) construction of canals and steam railroads; (2) adoption of steam power; (3) demand created by the Civil War; and (4) technological advancement in the industry.

Construction of canals and steam railroads accelerated the growth of population in the region. In addition, better connections with the large population centers in the Northeast and with sources of raw materials were provided. Adoption of steam power broke the industry's dependence on water power sites. The Civil War created a shortage of paper and raw materials. This condition stimulated an interest in raw materials other than rags. These raw materials,[4] some of which are abundant in the Lake States, were provided through chemical technological advancements in the industry.

An analysis of the present-day industry in the Lake States demands consideration of several facets. Among these, the distribution of manufacturing plants in the industry and the technology employed in the manufacture of the product are of prime importance. To a geographer, however, the chief interest lies in an explanation of the factors influencing the location of the component plants.

[1] "William Bradford, a printer, was one of the founders of the first paper mill in the British North American Colonies. In 1690 he, with William Rittenhouse and two others, started the first Rittenhouse mill on Wissahickon Creek in Germantown, Pa." (L. T. Stevenson, *The Background and Economics of American Papermaking*, [New York and London: Harper & Brothers Publishers, 1940] p. 7.)

[2] Cities furnished the raw material, rags, and supplied a market for the finished paper.

[3] For the purpose of this paper the Lakes States are considered to include those states west of the Appalachian Plateau which border the Great Lakes. The region includes Ohio, Indiana, Illinois, Michigan, Wisconsin, and Minnesota.

[4] Straw, wood hemp, jute, and cotton hull fiber.

Table 1.—Statistical Comparison of Selected Mills

Mill	Location	Yearly Production of Paper in Tons	Daily Consumption of Water in Gallons	Source of Water	Yearly Consumption of Coal in Tons	Source of Coal	Power Used Per Year
1.	Manistique, Michigan	25,000	1,000,000		25,000	W. Va.	
2.	Green Bay, Wisconsin	40,500	33,000,000	Fox R. East R.	70,000	W. Va.	10,000 K.W.H. of electicity
3.	Appleton, Wisconsin	15,000	6,000,000	Fox R.		W. Va.	2500 Water H.P. 2500 H.P. steam turbine
4.	Cloquet, Minnesota	96,000	37,000,000	St. Louis R.	85,000	W. Va. Pa.	96,342,750 K.W.H. electricity
5.	Detroit, Michigan	30,000	20,000,000	River Rouge	60,000	W. Va.	1,200,000,000 lbs. of steam and 30,000,000 KWH electricity
6.	Kalamazoo, Michigan	75,000	8,000,000	KalamazooR.	110,000	W. Va. Ky.	
7.	Escanaba, Michigan	50,000		Escanaba R.	70,000	W. Va.	
8.	Indianapolis, Indiana	20,000		White R. City Water			
9.	Chicago, Illinois	3,500			8,000		3,000,000 K.W.H. electricity
10.	Wausau, Wisconsin	25,000		Wisconsin R. Wells	20,000	Ohio Pa.	20,000,000 K.W.H. electricity

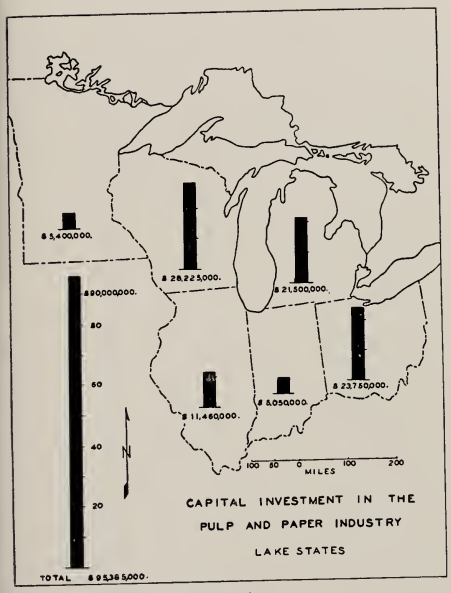

FIG. 1.

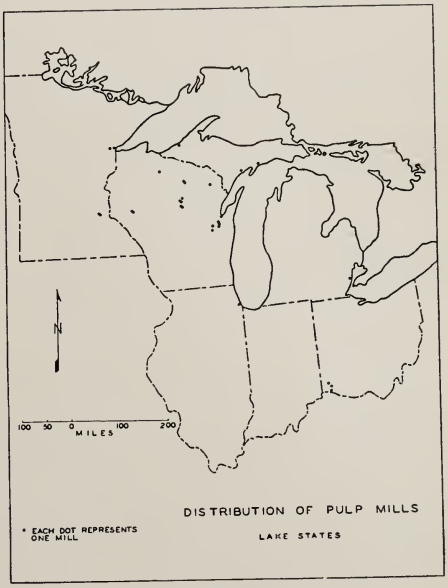

FIG. 2.

SCOPE OF INDUSTRY

Capital Investment.—The capital investment in the pulp and paper industry of the Lake States totals almost one hundred million dollars (fig.1).[5] The three states of Wisconsin, Ohio, and Michigan account for more than three-fourths of the total investment.[6] Of the remaining fourth, Illinois provided an investment exceeding that of Minnesota and Indiana combined.

Distribution of Plants.—Pulp mills are concentrated in two widely separated areas: Northern Wisconsin and Southwestern Ohio (fig. 2). Northern Wisconsin, the larger area, has numerous mills along the Fox and upper Wisconsin rivers. Three mills in Upper Michigan and four in Minnesota are on the periphery of the Wisconsin area. Southwestern Ohio, the smaller area, has its pulp mills concentrated in the Miami Valley. Isolated mills exist at Chicago and Detroit.

The paper mills are concentrated within a rectangle which is 250 miles wide and runs on a northwest-southeast axis from central Minnesota through Ohio (fig. 3). Only eight paper mills lie outside this rectangle. The pattern is characterized by marked nucleation and linear dispersion. Four nuclei are in: (1) the Fox River Valley; (2) the Kalamazoo River Valley; (3) Chicago; and (4) the Miami River Valley. Dispersed lines are coincident with three river valleys: (1) the Upper Mississippi; (2) the Upper Wisconsin; and (3) the Middle Scioto. In addition, isolated plants are located in other river valleys and in areas served by cheap transportation.

[5] Statistics were compiled from the *Thomas Register of American Manufactures*—Seventh Edition, Vol. II, 1947.

[6] Wisconsin, 29.5 per cent; Ohio, 24.8 per cent; Michigan, 22.5 per cent; Illinois, 12.0 per cent; Minnesota, 5.6 per cent; and Indiana, 5.2 per cent.

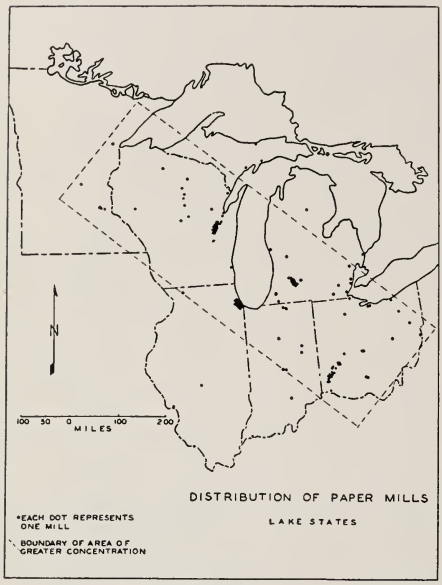

FIG. 3.

PRODUCTION PRACTICES

Use of Water.—The marked concentration of pulp mills and paper mills in river valleys reflects the heavy dependence upon the basic resource of water (Table 1). This resource plays a major role in pulp and paper production.[7] In one pulping process[8] water is played on huge grindstones to prevent burning. Large quantities of water are employed in other processes which employ chemicals.[9] In addition, water is used as the chief means of transport for carrying pulp to various stations throughout the plant. Power[10] to run the plant depends upon water, whether it is steam, hydro-electric, or thermo-electric. The importance of water, in another sense, is its use as a means of transportation for bringing raw materials to the plant and for carrying finished products from the plant. It is especially important for bringing coal to many of the manufacturing sites.

Use of Power.—Perhaps power occupies the position of importance secondary only to water in the manufacture of paper. Giant machines driven by thousands of units of power are necessary to produce the finished product. Mills commonly have their own power producing units. Power used may be one or more of four types: (1) water; (2) hydro-electric; (3) steam; or (4) thermo-electric. The latter two of these types depend upon the use of coal.

Use of Coal.—Mills annually use many thousand tons of coal per year (Table 1). West Virginia supplies most of the coal for the pulp and paper mills in the Lake States. The Great Lakes offer a cheap means of transportation which is utilized by many mills. Cheaper rates of transportation for these mills give them an advantage over mills which depend upon rail transportation for their coal supplies.

Raw Materials.—Wood pulp[11] constitutes most of the matrix purchased or manufactured for paper

[7] In a Cloquet, Minnesota, mill selected for this study, 37,000,000 gallons of water per day are used in a yearly production of 96,000 tons of paper. A Green Bay, Wisconsin, plant employs 33,000,000 gallons per day to manufacture 40,500 tons annually.

[8] Paper is chiefly cellulose in some form. Cellulose is the chief constituent of the solid framework of all leafy green plants. Pulping processes, although numerous and diverse, are all concerned with changing the cellulose of plants to paper. (Stevenson, *op. cit.*, p. 16.)

[9] Chemicals dissolve out all materials in the wood except cellulose. After the cellulose has been extracted it is washed to remove the cooking liquor.

[10] Early sites made use of water power.

[11] A notable exception is an Appleton, Wisconsin, plant which was selected for this study. This plant manufactures fine personal and business writing paper from cotton fibre pulp. The pulp is made of cotton cuttings from garment factories and of cotton linters. The cotton cuttings come from distributors in Chicago, New York, Rochester, and St. Louis. Cotton linters come from 450 cotton seed oil mills located throughout the south.

making in the Lake States. Sources of supply for mills which purchase their wood pulp are: (1) Canada; (2) Scandinavia; (3) New England; (4) the Pacific Northwest; and (5) the Lake States. The mills which manufacture pulp utilize several woods[12] from Canada, Wisconsin, Minnesota, and the Upper Peninsula of Michigan. The supply in these areas, however, is not great. This condition, if not corrected by conservation measures, offers the only threat to continued advancement of the industry.[13]

Eleven minor materials are included in the manufacture of pulp and paper. The chemical pulping processes employ lime and limestone, alum, sulphur, soda ash, salt cake, chlorine, and sulphate aluminum (Table 2). Filler of clay and starch and rosin size add body and finish to the paper. Some mills also make use of dyes.

Transportation. — Three methods of transportation serve the mills: (1) rail; (2) water; and (3) truck. Finished products, representing a great diversification of types of paper and paper board, go to all parts of the United States and foreign countries.[14] The greatest amounts, however, are destined for cities in the Lake States region. Large total population in the region provides a ready market for much of the production.

Table 2.—Source of Minor Raw Materials

Lime and limestone	Michigan
	Wisconsin
	Illinois
Sulphur	Texas
Soda ash	Ohio
Salt cake	Montana
	Canada
Chlorine	New York
	Michigan
Alum	Missouri
Rosin size	Wisconsin
	Alabama
Clay	Georgia
Starch	Illinois
	Iowa
Sulphate aluminum	Wisconsin
Dyes	Delaware

Factors Influencing Location of Mills

The foregoing analysis of technology employed in the production of pulp and paper demonstrates the factors which influence the location of mills. As in the early days of the industry, these locational factors primarily are: (1) a large volume of clear and pure water; (2) cheap power; (3) proximity to sources of the chief raw material; and (4)

[12] Spruce, balsam, poplar, aspen, jack pine, birch, tamarack, and hemlock.

[13] "The pulp and paper industry in the Lake State (the Lake States here include only Michigan, Wisconsin, and Minnesota) is not self-sufficient in local sources of raw materials. In recent years the region has imported about one-fourth of the pulp wood it consumes—mostly spruce and balsam from Canada. Scandinavian countries contributed a small part of the region's wood pulp needs prior to the late war and have resumed shipments on a limited basis. . . . The only new pulpwood logging areas of substantial size in the Lake States are in northern Minnesota, particularly within the boundaries of state and national forests. Seventy per cent of the Lake States' remaining supply of jack pine is in Minnesota and 33% is within the boundaries of the Superior National Forest. . . . The pulp and paper industry in the Lake States region is strategically located with regard to local and national markets. If sufficient attention is given to the problem of providing raw material, the industry can be maintained indefinitely and may even expand. However, there must be a change of attitude on the part of the industry toward the use of raw materials. The forest must be treated as a renewable resource rather than as a mine. Also, pulp wood operations must be integrated with those of other forest users.

"The 50 million acres of commercial forest land in the Lake States can meet the requirements of accessibility, productivity, and cheapness to reproduce if handled under proper management. More rapid forest growth rates in the South and West are offset by higher freight charges to national markets. Under normal conditions of competition, the pulp and paper industry of the Lake States has as good, if not better, opportunities for permanent and sustained production as those of any other region." (*Pulpwood Stands, Procurement, and Utilization* [New York: Technical Association of the Pulp and Paper Industry, 1947] pp. 40, 43, and 51.)

[14] Newsprint production has declined in the area. The high cost and increased scarcity of spruce has eliminated this product from the region. (Ibid., 40.)

proximity to markets. Transportation facilities must be added to this list. Availability of unskilled labor is also an important consideration in the location of present-day mills.

The Lake States area contains many sites which provide the chief factors influencing location of pulp and paper mills. At these sites mills have started, multiplied, and developed to proportions which place this region among the four outstanding in the country in the production of pulp and paper. The Lake States region has a good chance for continued and sustained production. The only real hazard to the future of the industry in the Lake States region lies in the possible failure to provide for the replenishment of pulp wood.

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GEOLOGY

PRESENT STATE OF KNOWLEDGE REGARDING THE PRE-CAMBRIAN CRYSTALLINES OF ILLINOIS*

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The oldest sedimentary strata of Illinois rest on a foundation of igneous and metamorphic rocks which are commonly referred to as the pre-Cambrian crystallines or basement complex. Rocks of corresponding age crop out in the nearby states of Wisconsin, Minnesota, Iowa, and Missouri, but in Illinois they are buried under a variable thickness of later sediments and can be examined only in cuttings or cores from deep wells.

Six wells in Illinois penetrate these crystalline rocks, one each in Boone and DeKalb counties, two in Lee County, and two in Pike County, figure 1. The four wells in the northern counties encountered granite, but the two southern wells encountered rhyolite porphyry and granophyre. From 3 to 639 feet of these ancient igneous rocks were cut in the various wells. All were drilled as oil tests and all but one, the Herndon Drilling Co.—Campbell well in Pike County, were drilled with cable tools.

Data regarding the names of the wells and their locations, the depth and sea-level elevation of the tops of the crystalline rocks, and their thickness and character are given in table 1. The greatest and least depths are 3845 and 2221 feet respectively. In terms of elevation, the highest occurrence is 1401 feet below sea-level and the lowest is 3046 feet below sea-level, a range of 1645 feet. As a measure of the local relief involved, the difference in elevation of the crystalline surface is 356 feet in the two Lee County wells which are five miles apart, and 1088 feet in the two Pike County wells which are 8½ miles apart.

FIG. 1.—Location of wells that penetrate pre-Cambrian crystalline rocks.

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TABLE 1.—PRE-CAMBRIAN CRYSTALLINE ROCKS IN ILLINOIS WELLS

Name of well	Location	Top of crystalline rocks		Thickness penetrated, feet	Type of rock encountered
		Depth in feet	Sea-level elevation		
1. Northern Illinois Oil and Gas Co. Taylor No. 1	28-43N-3E Boone County	2925	–2105	73	Gray granite
2. Paul Schulte, Wyman No. 1	35-41N-5E DeKalb County	3845	–2935	639	Red granite
3. H. O. Carr, Vedovell No. 1	35-20N-10E Lee County	3465	–2690	187*	Red granite and felsite
4. Amboy Oil and Gas Co., McElroy No. 1	30-20N-10E Lee County	3760	–3046	12	Red granite
5. Herndon Drilling Co., Campbell No. 1	15-4S-5W Pike County	3204	–2488	3	Red–brown rhyolite porphyry
6. Panhandle-Eastern, Mumford No. 1	21-5S-4W Pike County	2221	–1401	5	Red granophyre

* As of April 26, 1949; well reported shut down.

From the limited information provided by the six wells and the character of the topography of exposed and buried pre-Cambrian surfaces in nearby areas,[1] it is inferred that the buried pre-Cambrian terrain in Illinois probably ranges from a broadly undulatory surface studded with scattered residual hills to one featured at least in part by close-spaced hills and valleys, and that a local relief of as much as 1000 feet may be a common situation. Regional warping and local faulting and folding in post-Cambrian time have doubtless modified the original attitude of this terrain. It has been suggested that the crystalline surface becomes generally lower eastward from the Ozark dome region of Missouri and southward from Wisconsin until it reaches depths greater than 11,000 feet below sea-level in southeast Illinois.[2]

Study of cuttings shows that with the exception of altered felsite encountered in the H. O. Carr—Vedovell No. 1 well in Lee County, the crystalline rocks found in the four wells in the northern part of the State all are red or gray granites of medium to coarse-grained texture. The common essential minerals in-

[1] Buckley, E. R., Geology of the disseminated lead deposits of St. Francois and Washington Counties; Missouri Bur. Geology and Mines, Vol. 9, Part 1., pp. 17-18, 1909.
Weidman, Samuel, The geology of north central Wisconsin; Wisconsin Geol. and Nat. His. Survey, Bull. No. 16, pp. 385-395, 1907.

[2] Workman, L. E., and A. H. Bell, Deep drilling and deeper oil possibilities in Illinois; Illinois Geol. Survey Rept. Inv. 139, p. 2060 and figure 14. Reprinted from Bull. Am. Assn. Petroleum Geologists, Vol. 32, No. 11, 1948.

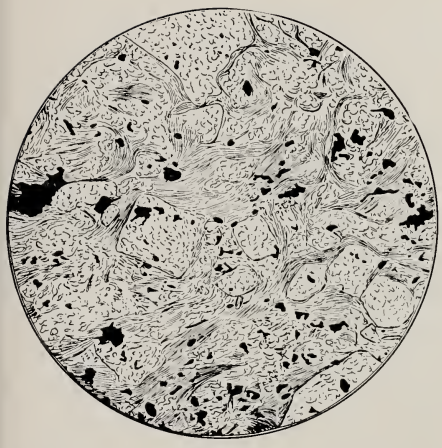

FIG. 2.—Sketch of microporphyritic felsite from dike in granite from H. O. Carr-Vedovell well, Lee County. Rectangular crystals represent altered feldspar; bundles of curving lines represent crystallites arranged in flowage pattern; black represents opaque minerals; and the rest is cryptocrystalline material. Magnification 120X.

clude quartz, orthoclase and microcline feldspar, and biotite. The common accessory minerals are apatite, zircon, rutile, magnetite, and ilmenite. Chlorite and epidote also occur in small amounts. Plagioclase feldspar is present in such small amounts as to be practically an accessory mineral; oligoclase and andesine are the varieties found. Hornblende is rare or lacking in all except the Northern Illinois Oil and Gas Co.—Taylor well in Boone County, in which it is abundant. The granite in the Taylor well also differs from the other granites in that it is grayer, contains abundant titanite, much of which is in large grains, and has andesine rather than oligoclase as its plagioclase feldspar. This difference in mineralogical character might result either from compositional variations within a single granite mass or from the presence of a separate and different body of granite at the Taylor well locality.

From a petrographer's point of view, the most interesting feature of these northern wells is the altered felsite found in the granite in the H. O. Carr—Vedovell well, which because of its much different textural character is presumed to occur as dikes intrusive into the granite. The well penetrated successively 95 feet of granite, 35 feet of altered felsite, 52 feet of granite, 7 feet of altered felsite, and finally 3 feet of granite. The least-altered particles of felsite recovered in the cuttings are reddish and purplish brown in color, and as seen in thin section, figure 2, are composed of numerous tiny square to rectangular crystals of altered feldspar in a matrix consisting of numerous crystallites and of cryptocrystalline material of indeterminate composition which may have been glass originally. The crystallites around many of the tiny feldspar crystals are arranged in a pattern suggestive of flowage while the mass was still partly fluid.

The felsite has been altered to a light green waxy clay, whose X-ray diffraction pattern is that of a mica-montmorillonite mixed layer mineral in which the proportion of mica to montmorillonite is about 5 to 1.[3] The progressive nature of this alteration, presumably by chemically active hot water which traversed fractures alongside or within the dikes, may be observed in the appearance of various fragments in the samples. It is reflected first in a change in color

[3] X-ray analysis by W. F. Bradley, Chemist and Head, X-ray Division, Illinois Geological Survey.

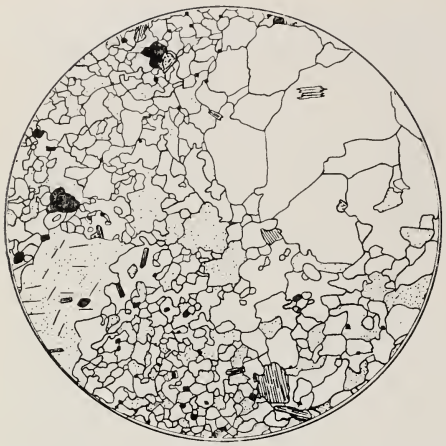

FIG. 3.—Sketch of rhyolite porphyry from Herndon Drilling Co.—Campbell well, Pike County. Clear grains are quartz, stippled are feldspar, black are mostly magnetite and pyrite, and grains with longitudinal lining are biotite and muscovite. Large areas of quartz appear as single grains in plain light. Magnification 48X.

FIG. 4.—Sketch of micropegmatitic texture in granophyre from Panhandle-Eastern-Mumford well, Pike County. Quartz (clear) is intergrown with feldspar (dashed line pattern). Black grains are magnetite. Magnification 33X.

from brownish to mottled shades of tan and greenish gray and a slight decrease in hardness, then by increasing dominance of the green color and further decrease in hardness until in the final stage the entire mass is changed to soft green clay. In thin section the original microporphyritic texture of the felsite is clearly preserved in the green clay, a further proof that the latter is an alteration product of the felsite. Additional evidence that this alteration was caused by hydrothermal solutions is afforded by the presence of small fluorite crystals in the upper part of the uppermost dike and in the 45 to 50 feet of granite overlying the dike, the somewhat altered appearance of the granite immediately above the uppermost dike, and the presence of moderately abundant pyrite in the green clay.

The crystalline rocks in the Pike County wells are distinct petrographically from the granites found in the northern wells. The rock from the Herndon Drilling Co.—Campbell well is a purplish-brown rhyolite porphyry and that from the Mumford well a granophyre. Both of these rocks are fine-grained members of the granite clan and both are types common in the pre-Cambrian exposures approximately 125 miles south in the St. Francis Mountain area of southeastern Missouri.[4]

The rhyolite porphyry in the Campbell well consists of large crystals of feldspar and quartz up to 7 millimeters long, comprising together about 20 percent of the rock, in a

[4] Erasmus Haworth, Crystalline rocks of Missouri: Missouri Geol. Survey, Bulletin 8, pp. 81-222, 1895.
Tarr, W. A., Intrusive relationship of the granite to the rhyolite (porphyry) of southeastern Missouri: Geol. Soc. America, Bull. 43, pp. 965-992, 1932.

fine-grained, equigranular, fresh-looking groundmass consisting of 60 percent quartz and 40 percent orthoclase feldspar, figure 3. Other minerals present include minor amounts of muscovite and biotite mica, chlorite, pyrite, magnetite, hematite, zircon, and garnet. The large feldspar crystals include microcline, orthoclase, and microperthite, and many of them have rectangular or partly rectangular outlines. The large quartz crystals are oval to lenticular in outline, and are made up of groups of interlocking smaller crystals. The edges of many of the large quartz grains are scalloped or embayed in the fashion commonly attributed to corrosion of early-formed crystals by the still-liquid portion of magma. Many of the large crystals have been fractured, either during flowage of the mass while partially liquid or as the result of later metamorphic shearing. The cracks in some of the crystals are filled with later quartz and in others by portions of the quartz-feldspar groundmass. Further evidence of flowage or shearing is faintly apparent in traces of banding caused by parallelism of the long axes of lenticular quartz grains and a slight color banding. In general, the equigranular mosaic texture of the groundmass and the completely random orientation of the micas suggest recrystallization as a result of metamorphism. The rock has been termed a recrystallized quartzite by some, but the large amount of feldspar in the groundmass and the general non-detrital appearance of both the individual crystals and the rock as a whole make this interpretation questionable.

The original character of the crystalline rock from the Panhandle-Eastern—Mumford well, the other Pike County occurrence, is more difficult to determine as the available samples consist entirely of fragments smaller than 1/8 inch. However, it is apparent that the rock is red in color and consists largely of quartz and the feldspars microcline and orthoclase. The very minor amount of accessory minerals includes magnetite, chlorite, zircon, fluorite, and pyrite. The overall texture is an uneven medium-grained mosaic of quartz and feldspar with a few larger rectangular microcline crystals which probably are phenocrysts. Thus the rock is probably a porphyry. The most conspicuous textural feature is the abundance of an intergrowth of quartz and feldspar in micropegmatitic fashion, figure 4. Porphyries of the type described are commonly termed granophyres and this name is therefore applied to the rock from the Mumford well.

In connection with the description of the crystalline rocks of Illinois, the Insane Asylum or City Sanitarium well in the city of St. Louis is of interest as it has been reported to have reached granite.[5] This well was drilled in 1869, at which time its depth of 3843½ feet, as originally reported, made it one of the deepest wells in the world. More recently the Missouri Geological Survey gives the total depth as 3883 feet[6] from which it is inferred that the well was deepened sometime in its history.

The original published log of the well reported that the last 40 feet

[5] Broadhead, G. C., On the well at the Insane Asylum, St. Louis County: Trans. Acad. of Sci. of St. Louis, Vol. 3, pp. 216-223, 1878. The occurrence of granite in this well is also mentioned in an anonymous note in American Jour. Sci. 3rd Series, Vol. 9, p. 61, 1875.

[6] Communication from Edward L. Clark, State Geologist, February 25, 1949.

drilled was hard red granite because cuttings contained grains of red quartz and feldspar[7] and this interpretation has been repeated in succeeding publications that made reference to the well. Lately the Missouri Geological Survey kindly supplied cuttings from the St. Louis well from depths of 3522 to 3848 to allow comparison of the reported granite with the granites in Illinois. Study of the samples indicates, however, that no granite or other crystalline rock was encountered, but that the material penetrated was entirely sandstone, in part feldspathic and shaly. Feldspar is present in the upper samples from 3522 to 3620, absent in the middle samples from 3620 to 3817, and increasingly abundant again in the lowermost samples. Mottled shale is present in various places. No mica was observed, nor any evidence that any of the quartz or feldspar grains came from the drilling of a quartzite or granitic rock. The most reasonable interpretation appears to be that the lower part of the St. Louis well to a depth of 3848 feet penetrated a thick sandstone section containing occasional feldspathic sandstone beds and beds of mottled shale.

[7] Broadhead, G. C., op. cit.

FACTORS AFFECTING LABORATORY MEASUREMENT OF PERMEABILITY OF UNCONSOLIDATED GLACIAL MATERIAL[1]

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Introduction

Many noteworthy contributions have been made by scientific research on the flow of fluids through porous media. The work has been mainly in two categories, consolidated material and filtration materials, with less attention to unconsolidated water-bearing materials. Many of the same problems confront the worker in all three fields, and much of the information and many concepts are interchangeable. There are, however, certain problems in the study of unconsolidated water-bearing deposits which are not encountered in the study of either filtration or consolidated material. The consolidated material tends to be more uniform in character (excluding materials with secondary porosity). Filtration material may be sorted, stratified, and of varying shape to obtain the desired results or effects. In natural unconsolidated water-bearing material, a marked heterogeneity is usually encountered; therefore a more empirical approach is necessary in their study.

Properties of Sediments

Classification.—Numerous methods have been devised to describe and classify sediments. Some are extremely useful whereas others are of limited use and little practical value. A brief review of some of the criteria is necessary to ascertain those which are pertinent to the present study. Krumbein[2] says of the mass properties of sediments, "Just as the behavior and functions of a complex organism are the sum of the behavior and functions of the component cells, so also is the character of the aggregate sediment (or any other particulate substance) a summation of the characters of the individual particles or grains of which it is made."

Packing.—An important factor which exercises control over both porosity and permeability is packing. Graton and Fraser[3] have recognized two classifications of packing, systematic and random. They have recognized six basic patterns for systematic packing, which range from loosest to closest packing. Random or disorderly packing is far more common in nature and therefore of more interest to the hydrologist and geologist.

They further state[4] that haphazard packing being of higher porosity than tighter rhombohedral packing has a larger average size of voids;

[1] Published with the permission of the Chief, Illinois State Geological Survey, Urbana, Illinois and based, in part, upon Master's thesis, University of Illinois.

[2] Krumbein, W. C. and Pettijohn, F. S., Manual of sedimentary petrology, p. 498, D. Appleton-Century Company, New York, 1939.

[3] Graton, L. C. and Fraser, H. J., Systematic packing of spheres with particular relation to porosity and permeability: Jour. Geol. vol. 43, pp. 485-800, 1935.

[4] Op. Cit., p. 876.

therefore it has a higher permeability. Since most haphazard packing is systemless, the voids are generally of non-uniform size, producing a higher permeability than systematic packing of the same porosity.

Porosity.—Porosity is the percentage of pore space in the total volume of the sample, i.e., the space not occupied by solid mineral matter. Fraser[5] has listed the following seven factors which control the porosity

1. Absolute size of grain.
2. Non-uniformity in size of grain.
3. Proportions of various sizes of grains.
4. Shape of grain.

Factors of more general nature include:

5. Method of deposition.
6. Compaction during and following deposition.
7. Solidification.

Size.—Slichter[6] in his theoretical work came to the conclusion that the absolute size does not affect the porosity. The factor which has been overlooked is that spherical particles were used instead of natural grains. Actually as grain size decreases, friction, adhesion, and bridging become increasingly important because of the higher ratio of surface area to volume and mass. Therefore, the smaller the grain size, the greater the porosity. Lee and Ellis[7] made determinations on 36 samples ranging from coarse sand to silt with the following results in percentage of total voids: Coarse sand, 39-41 percent; medium sand, 41-48 percent; fine sand, 44-49 percent; fine sandy loam, 50-59 percent. The average of the thirty-six samples was 45.1 percent. Smaller particles were found to give values ranging from 50 to 95 percent.

The variety in grain size in proportion of various sizes and degree of assortment must be taken into consideration in any study of porosity. A mechanical screen analysis can best express these variations.

Hazen,[8] in his experimental soil work, devised a method of gaining a simple quantitative expression of the degree of uniformity which he calls the uniformity coefficient. This is the ratio of the diameter of a grain that has 60 percent by weight of the sample finer than itself to the diameter of a grain that has 10 percent finer than itself. Results of other workers[9] have shown that the values used by Hazen are not always applicable to all types of material. However, the variation is so slight that it does not seem necessary to change the values. Hazen further noted that uniformity coefficient would range from a value of 1, if all particles were of the same size, to 20 or 30 for heterogeneous material; that is, the coefficient increases as porosity decreases. A rough estimate of the open spaces can be made from the coefficient of uniformity. Sharp-grained materials having uni-

[5] Fraser, H. J., Experimental study of the porosity and permeability of clastic sediments: Jour. Geol., vol. 43, p. 916, 1935.

of natural unconsolidated deposits.

[6] Slichter, C. S. Theoretical investigation of the motion of groundwaters: U.S.G.S., Nineteenth Annual Report, 1897-98.

[7] Lee, C. H. and Ellis, A. J., Geology and groundwaters of the western part of San Diego County, California: U.S.G.S., Water Supply Paper 446, pp. 121-23, 1919.

[8] Hazen, Allen, Some physical properties of sands and gravels with special reference to their use in filtration: Mass. State Board of Health, 24th Ann. Rept., p. 70.

[9] Terzaghi, Karl and Peck, R. B., Soil mechanics in engineering practice, pp. 21-22, John Wiley and Sons, 1948.

formity coefficients below a value of 2 have nearly 45 percent open space as ordinarily packed, and sands having coefficients below 3 as they occur in banks, or artificially settled in water, will usually have 40 percent open spaces. With more mixed materials the closeness of packing increases until, with a uniformity coefficient of 6 to 8, only 30 percent open space is obtained, and with extremely high coefficients almost no open space is left. With round-grained water-worn sands the open space has been observed to be from 2 to 5 percent less than for sharp grains of similar size.

Permeability. — Permeability as defined by Tolman[10] is the capacity of water-bearing material to transmit water, measured by the quantity of water passing through a unit cross-section in a unit time under a 100 percent hydraulic grade. Many factors influence the permeability, including size of interstitial openings, continuity of openings, surface tension, capillarity, size of grains, absolute viscosity of fluid (in centipoises), and dissolved gas. It is beyond the scope of this paper to delve into all the hydrologic aspects, but they should be recognized. Although dependent on porosity, there is no direct ratio between porosity and permeability. Terzaghi and Peck[11] have stated that "when a soil is compressed or vibrated, the volume occupied by its solid constituents remains practically unchanged, but the volume of voids decreases; as a consequence the permeability of the soil decreases."

[10] Idem, p. 114.
[11] Idem, p. 44.

With openings of capillary and sub-capillary size the molecular attraction of water molecules is sufficient to "lock" the water in the interstitial spaces.

Surface tension of fluids.—Surface tension in fine-grained sediments exercises important control. It has been estimated by King[12] that the surface area in a cubic foot of sand composed of particles 0.02 millimeter in diameter is about 50,000 square feet. It is apparent that a considerable amount of water can be contained as a thin film on the surface of the grains of such fine material, and that molecular cohesion causes any remaining interstitial space to be filled with captive water. It can be demonstrated that in a given volume of material in which all factors other than size remain equal, the total interstitial space varies inversely with the size of the interstices. A half-inch sphere has one-fourth the surface area of a one-inch sphere, but a container of one cubic inch capacity will hold eight half-inch spheres which in effect doubles the interstitial surface.

Shape.—The shape of particles is known to affect both porosity and permeability, but thorough quantitative work on this aspect has been meager.

Shape studies.—Shape studies[13] were conducted to see whether a measurable quantitative relationship exists between shape, porosity, and permeability. An arbitrary scale[14] was set up based upon three shapes,

[12] King, F. H., A text of physics of agriculture, Madison, Wis., p. 124, 1900.
[13] Wadell, H., Sphericity and roundness of rock particles: Jour. Geol., vol. 41, pp. 310-331, 1933.
[14] Rittenhouse, Gordon, Analytical methods as applied in petrographic investigation of Appalachian Basin, U.S.G.S., Circular 22, March, 1948.

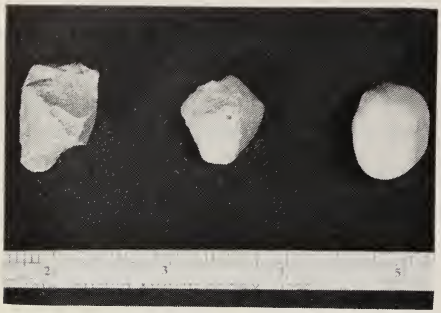

Fig. 1.—Selected pebbles used as a guide in shape studies.

rounded, semi-rounded, and angular. Three specimens were picked from the samples and photographed. This photograph (fig. 1) was used as a guide in further grain counts.

A piece of metric cross-section paper placed between two pieces of lucite served to delineate a given area. Small portions of a sieved sample were placed on the ruled piece of lucite and examined under a microscope. Grains within a given area were counted and an estimate was made of the percentage of each of the three shapes. A less rapid but more accurate method would be to make counts from photomicrographs.

Methods of Analysis

It can be readily seen that to the hydrologist permeability is much more important than porosity. A sediment which possesses porosity but not permeability is useless as an aquifer.

Numerous graphical and statistical methods have been devised by various workers in an attempt to analyze sediments. A review and appraisal is desirable to ascertain which of these methods is pertinent to the present problem.

Mechanical size analysis.—Two common and widely used statistical devices are the histogram and the cumulative curve. There are certain limitations and variations attendant to these methods, some of which are discussed below. Udden[15] was among the first workers in the field of sedimentation to use histograms. He observed that histograms of sediments varied considerably according to the type of sediment involved. Beach sands have well defined modes whereas glacial till fractions are widespread and irregular and often bi-modal. One of the greatest difficulties involved in the use of the histogram is caused by the choice of class intervals used in an analysis, i.e., its shape varies according to the particular class limits which are chosen. It is therefore quite possible to construct two very unlike histograms from the same sediment merely by using different class intervals. The basic difficulty with the histogram is that it appears to illustrate continuous frequency distribution as though it were made of discrete classes. Hence the histogram may not furnish much visual information about the frequency distribution considered as a continuous variation of size.

The use of the cumulative curve was prompted by the difficulties encountered in the histogram. This curve remains fairly constant regardless of the class limits used, whereas the histogram is definitely affected by a choice of class limits. Thus the cumulative curve is a much more reliable index of the nature of continuous distribution of particles of sediment. Another advantage of

[15] Udden, J. A., The mechanical composition of wind deposits, Augustana Library Publications, No. 1, 1898.

this curve is the ease with which other statistical data may be derived from it.

Size analysis coefficients.—One of the most valuable measures is that of the median, which is the mid-point in size distribution of the sediment of which one-half by weight is composed of particles of smaller diameter than the median and one-half is composed of particles larger than the median. This is readily obtained from the cumulative curve by noting the diameter at the intersection of the 50 percent line and the curve. This value is used in the recommendations for well screens by the Illinois State Geological Survey.

Skewness, or the measure of the degree of asymmetry of the cumulative curve, has been recommended by some as a method of ascertaining the sorting; that is, a positive skewness indicates that a preponderance of the sample lies on the coarse side of the median. A negative skewness would indicate the opposite. The use of skewness currently has little practical application, mainly because relatively little is known of this character of sediments. Sampling errors, selective transportation, and other factors often manifest themselves as skewness.

Effective size was a term developed by Hazen[16] in his work on filtration sands to designate the diameter of the size particle of which they were 10 percent of the sample by weight smaller and 90 percent by weight larger. Although this measurement was derived for use on a certain sediment, it has with some modifications been quite generally accepted. The effective size is readily obtained from the cumulative frequency curve by ascertaining the point at which the 90 percent line intersects the curve. Hazen justified the choice of effective size upon his observations that the finest 10 percent of a sample has as much effect on the properties as the coarsest 90 percent.

Trask[17] has proposed a method of expressing the measure of the average quartile spread, the coefficient of sorting. It is determined by the square root of the third quartile diameter divided by the square root of the first quartile diameter. This method eliminates the size factor, that is, differences in coarseness between samples or units of measures have no effect on the coefficient of sorting. This method gives a relative idea of the sorting in terms of well sorted (less than 2.5), medium sorted (about 3.0), and poorly sorted (4.5 or more), but fails to give an accurate quantitative measure.

Krumbein and Monk[18] conducted experiments on unconsolidated glacial sediments to determine the effect of size perameters on permeability. The results of their work are of little value in this study because their samples were artificially compounded to fit a predetermined curve, that is, the sieve separates were mixed so that the mean and standard deviations could be varied at will.

Drilling and sampling techniques. The technique in obtaining well samples varies greatly from the techniques used in other methods of sam-

[16] Idem, p. 432.

[17] Trask, P. D., Origin and environments of source sediments of petroleum: Nat. Research Council, Rept. Comm. on Sed., pp. 67-76, 1932.

[18] Krumbein, W. C. and Monk, G. D., Permeability as a function of size perameters of unconsolidated sand: Amer. Inst. Min. Met. Eng. Inc., Petroleum Technology, July, 1942.

pling. It is impossible to remove the material of well samples in an undisturbed condition. Material which has slumped from higher levels in the well bore often contaminates the samples, and drilling bits often pulverize or otherwise disintegrate particles, thus distorting their true magnitude.

The type of drilling tools, the methods used, the size (diameter) of the hole, and the type of well (test hole or producing well) must be considered in the study of any given sample.

Most wells are drilled by one of three different methods—rotary, cable tool, and reverse hydraulic. Certain characteristics of each method merit discussion.

Cable tool or percussion drilling is accomplished by repeated raising and dropping of a bit and a heavy string of tools suspended on a cable or by driving casing and cleaning out the debris as the casing is forced downward, or often by a combination of the two operations.

It is difficult to obtain representative samples from cable tool bore holes. The upper portions are often drilled "dry," that is, with just enough water to facilitate drilling and bailing operations. When a water-bearing sand is encountered, the bore hole is loaded with fluid to, or in excess of, hydrostatic balance with the formation in order to prevent heaving. Heaving can cause drilling difficulties as well as contamination of samples. The constant influx of sand from a heaving formation makes it difficult or impossible to ascertain the true position and character of the water-bearing zone. Excessive disintegration of material is often caused by certain operations of the drilling procedure. Casing set with a drive shoe tends to disturb the formation, and failure of the bailer to remove cuttings exposes them to repeated blows from the drilling bit. The importance of a good and experienced driller cannot be overemphasized. It is generally the driller who collects samples, and the validity of the samples is largely dependent on his care, knowledge, and experience.

In rotary drilling, mud is of prime importance. Many holes drilled in glacial drift utilize as drilling mud the clay material found in the upper portion of the drift, adding only water. When sandy zones are encountered, additional fine-grained material, such as bentonitic clays, must be added by the driller to maintain the mud at the proper weight and viscosity and to remove the cuttings. In some cases, lime, cement, or other materials may be added to increase viscosity or weight.

Care in removing samples is necessary. A device similar to a wire box is generally used to slow up the flow of mud sufficiently to allow even the finer parts of the sample to settle before the sample is removed.

Hole size is an important consideration in the study of well samples. For example, in the large diameter wells drilled for the Illinois Water Service Company, a larger percentage of coarse particles were brought up and a larger percentage of fine particles were washed away than in the 4-inch rotary test holes drilled on the same sites.

As would be expected, information from a test hole tends to be more reliable. More care is taken in sam-

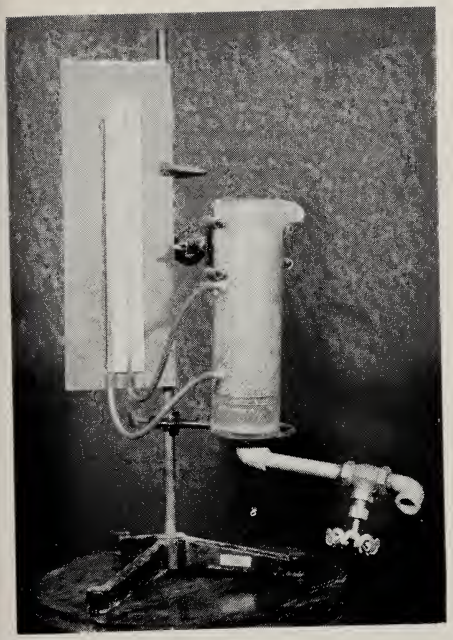

Fig. 2.—Device for measuring permeability of unconsolidated material.

pling and in other techniques. In most final wells, production is the ultimate goal. Large diameter wells produce so much material that a considerable disposal problem results, and it would be necessary to conduct a regular sample splitting procedure in order to obtain a representative sample.

Results of Studies

Permeability. — Samples used in the permeability experiments were composite samples derived from the entire water-bearing portion of University of Illinois Well No. 10. A limited number of readings were taken on 60- and 80-mesh sands and BB shot. It was of interest to note the slight variation between loosest and closest packing in the case of the 60- and 80-mesh separates. When wet samples were introduced into the permeameter containing water, they settled in a state of closest packing and any attempts to lower the permeability were fruitless.

Permeability testing.—Permeability was measured by allowing water under a 100 percent gradient to pass through a sample of known cross section and height, and measuring the amount which was passed in a given time. A permeameter was constructed of a lucite cylinder with an inside diameter of approximately 6.4 cm. and a length of 30 cm. A disc of lucite was bonded to the bottom of the tube and tapped for a ⅜ inch street *el* to which was connected a gate valve. Approximately one inch from the bottom of the tube a piece of 60-mesh wire was placed between two rings of lucite and reinforced with hardware cloth. Above this screen two openings were tapped 10 cm. apart and connected to manometer tubes which were mounted on a board with metric scales (fig. 2).

The major problem was obtaining uniform and accurate readings. To accomplish this a system of "average readings" was devised. Material was introduced into the tube in a steady stream until the top manometer opening was covered. No attempt was made to pack the material further. Water was then introduced into the tube from the top until a steady stream was obtained at the outlet, at which time a reading was taken. This first reading was taken immediately after a continuous flow was obtained through the gate valve, and recorded the permeability of the material in loosest packing.

After the permeability of the material was obtained in a condition of

loosest packing a "Vibra-Tool" was used to jar the material into the closest packing possible. The flow of water was stopped during the packing process to prevent the possibility of channeling. When the closest packing possible was obtained another reading was taken. The average of the two readings was then calculated, which, in the opinion of the writer, represents most closely the original permeability of the material in place in the ground. This conclusion was reached after it was demonstrated that it was possible to produce in the laboratory both looser and closer packing than a sediment possessed in nature. By using an average of loosest and closest packing it was possible to obtain more uniform results than could be obtained by attempting to pack each sample to a uniform standard.

Several experimental readings were made in order to develop a standard procedure which would give uniform results. It was found that false results could be obtained by surging the column of sediment and allowing a relatively complete sorting to take place in the tube. Channeling was common when higher velocities were used. These channels, when developed, allowed water to flow through the column of material in a quantity far greater than in unchanneled material.

The necessity for a gate valve to control the rate of flow of water through the column of material became apparent immediately. Materials of high permeability allowed turbulent flow to develop, introducing error into the results. A high rate of flow also allowed sorting and channeling to occur, causing intolerable errors. Several readings were taken on one sample allowing different amounts of water to flow through the tube in a given time; in all cases the results were well within the limits of probable error. It was then decided to use as low a rate of flow as would register a head on the manometer gauges, thus minimizing any effects due to turbulent flow or sorting.

Hydrologic tests.—A non-equilibrium formula for determining permeability and transmissibility by well pumping tests has been developed by Theis[19] and others. This formula has been applied to a number of well tests in Illinois and apparently gives a relatively reliable indication of the permeability and transmissibility of glacial drift aquifers in place. The values so obtained are controlled by the local natural variations in porosity and permeability (and packing) plus whatever changes may have been caused by drilling and development techniques at the particular site. In one instance in the Champaign-Urbana area, the calculated transmissibility based upon the Theis formula lies about half way between the limits of permeability determined in the laboratory for maximum open packing and maximum closed packing determined with materials from the well. Other cases indicate that the aquifer transmissibility based upon such pumping tests can always be expected to be within such limits, but that the production from a well cannot be predicted from laboratory analysis.

Several factors govern the amount of water which may be derived from

[19] Idem, pp. 519-524.

a formation. Of these, proper development of the well is of great importance. In sand and gravel strata it is quite possible to over-develop a well to a point where a failure is caused in the "roof" or overlying formation. If the overlying formation is composed of clay or extremely fine sand, this material will enter the well bore, causing the material near the well to be clogged and reduced in permeability. Over-development may also cause a bridging of the fine particles between the larger ones. This condition can be generally remedied by surging, and is not considered as detrimental to the yield as roof failure.

Under-development may also cause a low yield. This occurs when insufficient pumping and surging fails to cause relatively complete sorting.

Size range of the particles and thickness of the formation have great effect on the yield of a well, as noted above. Material with great uniformity of particle size will not yield much more water after development than before.

The amount of water available and the diameter of the well are important factors in determining the yield of a well. If there is sufficient water, it is possible to utilize large diameter wells which are capable of transmitting larger quantities of water to the surface than wells of smaller diameter. A thick formation for obvious reasons is capable of containing more water than a thin one.

The factors concerning the development of wells are largely dependent on the skill and experience of the driller. In any study it is important to take cognizance of this factor.

In the shape studies conducted by the author, it was possible to determine accurately the percentage of rounded, semi-rounded, and angular grains in any given sample. However, in any consideration of porosity and permeability, the indeterminate factor of packing still remains. When dealing with uniform spherical particles Graton and Fraser[20] have shown that there are six types of systematic packing, and that porosity and permeability are definitely related to packing. Instead of dealing with six combinations as in the ideal case, it appears that in glacial drift, which is neither uniform nor spherical, an infinite number of combinations of packing can exist. Due to the extreme variability of size and shape, classification as to packing is meaningless. Therefore, any attempt to predict porosity and permeability of a finished well from laboratory samples by any mathematical or experimental process is impracticable.

Summary and Conclusions

Experimental procedure in attempting to produce uniform permeability readings illustrated very clearly that the permeability determinations in the laboratory are not indicative of the actual permeability in the formation surrounding the well bore. An experienced driller, by properly developing a well, causes its yield to differ greatly from those indicated by laboratory permeability results.

The development of a well consists of increasing the permeability of the formation in the vicinity of the well bore, which may be done by pumping and surging to remove the

[20] Idem, pp. 785-800.

fine particles from the vicinity of the well bore. The coarser sand or gravel remain behind the screen in the well bore. The entire water-bearing formation for a wide area around the well is made more uniform in grain size, affording the greatest possible voids for the water to pass through. In proper development the size of the particles gradually decreases with distance from the well bore, and the particles become firmly lodged together and stabilized so that no further change occurs. It appears impossible to predict accurately the amount of water which may be derived from a well treated in such a manner, although experienced drillers can often make remarkably accurate estimates.

After due consideration of existing studies and in the light of the present study, it becomes apparent that there is no way to evaluate quantitatively and accurately the effects of such features as roundness, size, shape, porosity, and permeability in a heterogeneous or nonuniform material with respect to its ability to produce water. In all previous works of this nature the material studied was either artificial or the original character of the natural sediments was altered to conform to desired conditions. While these studies are of academic interest they have been found to be of small value to the practicing groundwater geologist.

The use of compound samples was considered best because the production figures computed for a water well represent only the production obtained from the entire section rather than production from any single stratum.

It is concluded that the use of grain shape in predicting the yield of a formation is not practical because the effect of shape on permeability is exceeded by the effects of grain size and the manner of packing. In evaluating the factors which control porosity, permeability, and well productivity from glacial drift aquifers, it is apparent that for any given texture the effect of packing is of sufficient magnitude to minimize the effects of all other factors, so that the primary influence on an aquifer's productivity are the original conditions of deposition and its subsequent history as affecting its packing.

Acknowledgement

The author wishes to express his gratitude to Carl A. Bays, formerly Head of the Division of Groundwater and Geophysical Exploration of the State Geological Survey, for his many suggestions and the critical reading of the manuscript, to the individual members of the groundwater division staff for consultation and suggestions, and to H. E. Hudson and H. F. Smith, engineers of the State Water Survey Division, for data, suggestions, and criticism.

FACIES ANALYSES OF THE NIAGARAN ROCKS IN ILLINOIS

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The Niagaran exposures in Illinois, which occur widely separated in the northeastern, northwestern, west-central, and southwestern parts of the State, contrast sharply in gross lithologic aspects as well as local facies development. The differences in gross lithology are basically expressions of broad regional facies differentiations. These regional sedimentation conditions are greatly modified in the two northern outcrop sections by a local environmental factor, the reefs, which formed local sediment sources. Complex small scale facies differentiation characterizes the reef enclosing strata here, indicating further the controlling effect that the reefs had on the sedimentation of the surrounding bottoms. These reef-bearing northern deposits stand out in sharp contrast to the reef-free southwestern Illinois deposits. The southwestern Illinois deposits consist entirely of normal shelf sediments, whereas the reef-bearing portion of the northern Illinois sections embrace reef and inter-reef deposits.

In broad environmental terms we may distinguish three major categories in the facies analyses: normal shelf deposits, reef deposits, and inter-reef deposits.

The normal shelf deposits consist principally of two recognizable source components: (1) terrigenous clastics, derived from the bordering land areas, and (2) skeletal debris, both calcareous and siliceous, supplied by the organisms that populated the shelf bottoms. The terrigenous clastics were apparently derived chiefly from the Appalachian upland or its southern extensions, and to a minor extent from the Ozark Island that existed in Niagaran time. Only in the Ozark bordering outcrop areas in southwestern Illinois do we find evidence of a major contribution of Ozark derived sediments. As to the other outcrop areas, their contributions appear to have been largely confined to the Joliet deposits of west central Illinois and the basal Joliet deposits of northeastern Illinois. There is no evidence at present to warrant the recognition of a chemical precipitate constituent in the carbonate fraction of the normal shelf deposits.

The reef facies differs radically from the shelf facies, as well as the inter-reef facies, in that it constitutes isolated bodies of essentially pure carbonate rock which is entirely organic in origin except for the secondarily introduced magnesian element. The reef frame was erected solely by reef-building organisms, principally stromatoporoids and tabulate corals, which produced rigid topographically raised structures that extended from the surrounding bottoms upward into the agitated surface waters. The interstices of the reef frame are largely filled with organic skeletal debris of reef dwell-

ing organisms and reef detritus, which occur commonly cemented into the frame by encrusting stromatoporoids. The reef bodies are commonly found flanked by reef-derived detritus. Secondary dolomitization has greatly altered the original textures and largely obscured the organic character of the reef bodies.

The inter-reef facies, up to the present ill-defined and interchangeably referred to as normal or lagoonal facies, may be broadly defined as the deposits which accumulated within the orbit of the detritus laden waters of reef outwash. The inter-reef deposits thus embody two distinct source elements, a regional and a local reef-derived one, the latter forming the most characteristic criterion for distinguishing the inter-reef facies from the normal shelf facies.

With this as a background, the facies of the individual outcrops may be analyzed.

Beginning with the northeastern Illinois outcrops, the Niagaran deposits consist of a succession of normal shelf deposits through the Joliet formation, which gradually gave way in the Waukesha transition phase to reef and inter-reef development in the Racine-Guelph formations. The regional environmental factors which can be deduced from the gross character of the sediments as a whole are fairly muddy waters (as indicated by the average of 15-20 percent terrigenous clastics) and soft muddy to sandy bottoms, generally lying slightly below effective wave base. Reef growth started in sporadic form during Waukesha deposition, which is marked by semi-rough water conditions and the influx of coarse silt and very fine sand. Curiously enough the main phase of reef development came only after lowering of the sea bottom below wave base, implying that deeper bottoms and fairly muddy waters were not detrimental to the Niagaran reef builders. Complex facies differentiation goes hand in hand with the main reef development, the inter-reef facies shifting horizontally and vertically in correspondence to the shifting reef spread. The inter-reef deposits are characterized by sharp horizontal f a c i e s differentiations ranging from quite muddy deposits of anaerobic through aerated quiet water facies all the way to rough-water deposits which are principally composed of reef-derived detritus. The inter-reef deposits thus contrast sharply with the early Niagaran normal shelf deposits; such facies changes as were gradually attained in time but not in space in the shelf deposits can be commonly found developed over short distances in the horizontal plane among the inter-reef deposits.

In the northwestern Illinois section, the Niagaran deposits also consist of a succession of normal shelf deposits in the Waukesha formation, followed by reef and inter-reef development in the Racine-Port Byron sequence. The facies contrast between normal shelf, reef, and inter-reef deposits is here less sharply defined, the chief contrasting features being sediment structures and facies shifts. This is primarily due to the negligible content of terrigenous clastics which average here less than 5 percent. Textural and composi-

tional criteria readily recognizable in limestones, which would aid in the analyses of a more detailed facies differentiation, have been obscured by secondary dolomitization. The broad environmental factors that characterize (and at the same time contrast) the northwestern and northeastern Illinois deposits are prevalent shallow-water bottoms, located largely above wave base, and clear water conditions. During the prevailing intervals of shallow water conditions, reef detritus was spread and redeposited entirely over the adjacent inter-reef bottoms, largely in the form of shifting sand bars rather than in detrital fans which, however, accumulated around reefs during periods of temporary subsidence below wave base.

The Niagaran deposits of west-central Illinois, as far as preserved, underlying the pre-Middle Devonian erosion surface, consist entirely of normal shelf deposits. As even the most extensively preserved sections in the Grafton area do not extend upward into the horizons of the reef-bearing strata in the northern outcrop areas, it is uncertain whether reef and inter-reef facies were originally present or not. The sections in the Hambury area consist of crinoidal limestone coquinas, of the semi rough-water type, whereas the Grafton deposits comprise dolomitized rough-water deposits at the base followed by semi rough-water deposits of the Waukesha facies type as developed in northeastern Illinois.

The southwestern Illinois deposits are represented in their entirety by normal shelf deposits in which the carbonates consist of limestone. Following an intial phase of semi rough-water conditions marked by clastic semi coquinas, the bulk of the succeeding section is composed of muddy bottom, quiet water deposits, evidently laid down at greater depth than any of those of the other outcropping areas. The prevailingly low density in burial population (consisting of small fragile forms) and lack of evidence of large scale reduction of the terra rosa muds derived from the adjacent Ozark upland point toward deposition under quiet water conditions, near or at the photosynthetic ceiling. Because of the pronounced muddiness, reflected in the terrigenous clastic content of about 40 percent, a considerably higher average than in any of the other areas, the photosynthetic ceiling was evidently above 600 feet, appreciably higher than its maximum extent under clear water conditions.

PHYSICAL CHARACTERISTICS OF THE OOLITE GRAINS OF THE STE. GENEVIEVE FORMATION*

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The usual hand specimens and thin sections of oolite afford randomly oriented cross-sections of the oolite grains and permit observation in one plane only. They give inadequate information therefore regarding the size, shape, or roundness of the grains. It was found that "chalky" oolite could be successfully disintegrated to yield a high percentage of discrete grains by a procedure known as the "sodium sulfate soundness test"[1] which duplicates roughly the disruptive action of freezing water but produces disintegration more rapidly. The quarry at Anna, Illinois, contains in its upper part a bed of Ste. Genevieve oolite 6½ feet thick which responded well to this procedure. This paper describes the results of a study of the oolite grains freed from six samples taken from the bed, each sample representing a vertical thickness of about 12 inches.

After disintegration each sample was screened into Wentworth size-scale fractions and weighed. The weight and number of oolite grains in a small weighed quantity of each size fraction was then determined and their particle size distribution calculated in percent by weight and percent by number.

Two matters bear critically on the confidence with which subsequent data may be regarded, namely, is the number of unbroken, discrete oolite grains proportionate to the number in the original sample, and to what extent did the disintegration process reduce the size of the freed grains by exfoliation of concentric deposits. Estimates of the abundance of oolite grains indicate that the number freed is roughly proportionate to the number in the original sample. Signs of exfoliation were generally absent in the discrete grains. This evidence and the excellent preservation of small fossils freed along with the oolite grains suggest that exfoliation was probably not an important phenomenon.

Size of Oolite Grains

The results of particle size determinations on the oolite grains in the six samples are shown in Figure 1. Most of the grains are between 0.25 and 0.83 millimeter in diameter. In terms of the Wentworth size scale for sediments, the grains are principally medium and coarse grained if considered on the basis of percent by weight. However, in terms of percent by number the dominant size is medium grained.

The particle-size histograms of the different samples show no consistent trend from the top of the bed downward. Mostly such variations as occur are between the medium- and coarse-grained grades.

The bedding and other characteristics of the stratum from which the

[1] A.S.T.M., Designation C88-46T.

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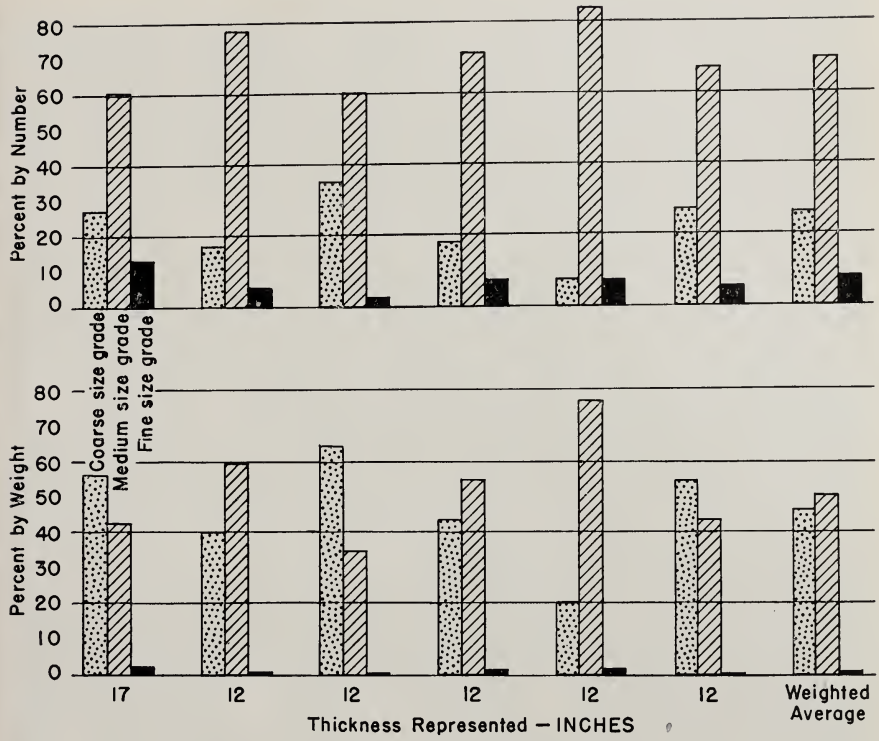

FIG. 1.—Particle-size distribution of oolite grains by weight and number. Reading from left to right the histograms progress from the top of the bed downward.

samples studied were obtained show clearly that it is a clastic rock. The particle-size data indicate conditions of sedimentation which appear to be even more selective than those under which a medium- and coarse-grained sand would be deposited. The restricted size range of the majority of the grains, about 0.6 mm., may be the result of either a high degree of sorting by the transporting medium, limiting factors controlling the maximum and minimum size of oolite grain development, or a combination of both. Erosion during transportation might also be responsible, at least in part, for the grain-size distribution. If this were true, very fine-sized oolite grains should be present. Also, some grains should show evidences of erosion, such as exposure of their internal structure. As neither of these phenomena was observed it is concluded that erosion of grains did not significantly affect particle-size distribution.

Taken together, the foregoing data suggest that the source of the oolite grains was not far from their site of deposition, that they were transported by relatively strong currents or waves, and that conditions in the area of oolite grain formation may have been such as to restrict maximum and minimum oolite size, especially the former.

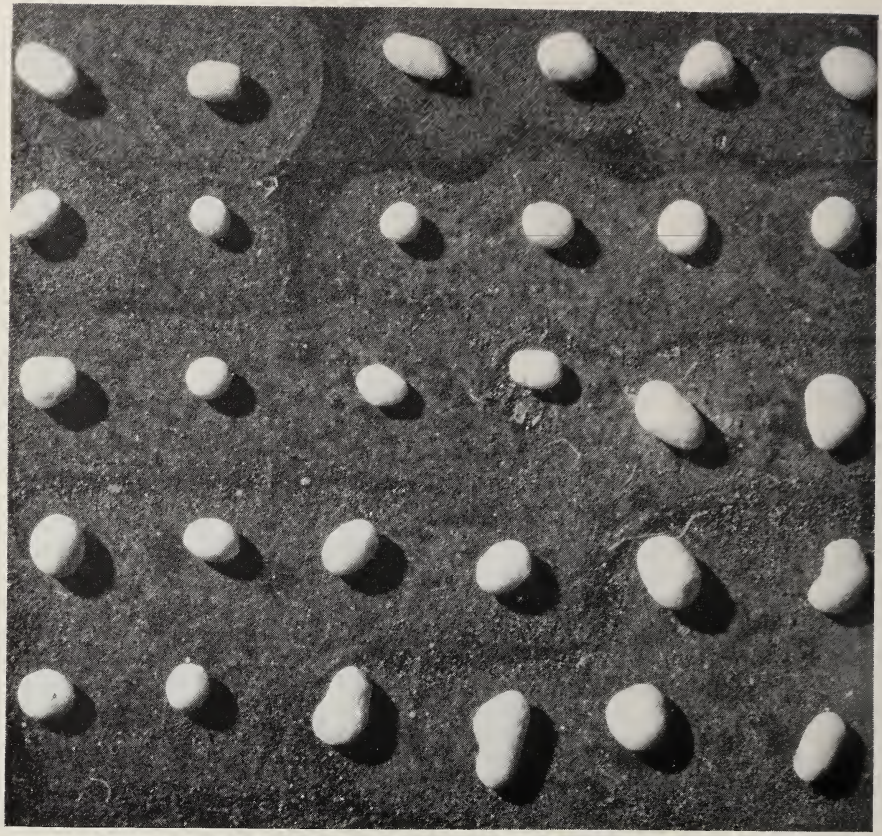

FIG. 2.—Typical oolite grains from the coarse size grade. X 10.

SHAPE AND ROUNDNESS OF OOLITE GRAINS

Roundness determinations were made from photographs of 60 grains of each size category selected at random from the various samples. Figure 2 shows grains of the coarse sand grade. Figure 3 gives the results of classification of the grains by Krumbein's scale for roundness determination.[2] The arithmetic mean roundness values on the chart are very similar and indicate little difference in the over-all roundness of the size fractions. The coarse sand fraction, as shown by the histograms, is notably different from that of the other two size-grades. One difference is the longer 0.9 roundness bar and the shorter 0.8 and 0.7 bars. This may be interpreted as being the result of increasing roundness accompanying the growth of the oolite grains. The reason for the greater percentage of grains with 0.6 roundness in the coarse sand grade is not understood. There is some evidence, however, which suggests that the centers in these oolite grains have

[2] Krumbein, W. C., Measurement and geological significance of shape and roundness of sedimentary particles, Jour. Sed. Pet., vol. 11, pp. 64-72, 1941.

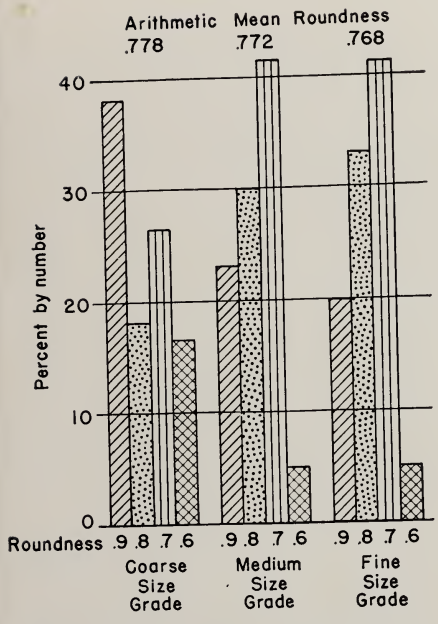

Fig. 3.—Roundness of oolite grains by size grades. Arithmetic mean roundness value is shown above each histogram.

low sphericity, are fossils or comparatively large fragments of fossils, or other types of material, and that the number of concentric deposits is small and therefore insufficient to eliminate the original angularity of the central grains.

Interesting light is shed on the reliability of roundness or shape interpretations from thin sections by a consideration of figure 2. It is evident that random sections through the oolite grains would be very misleading in many cases. A diagonal section through the elongate grains in the upper left hand corner would show an oval cross-section whereas a section at right angles to the long axis would give a circular section. Similarly erroneous results would be obtained with many of the oval or roughly triangular grains.

Summary

The oolite grains of the Ste. Genevieve limestone bed studied have the size characteristics of a well sorted medium- and coarse-grained sand and do not appear to have been transported far. Their roundness values are all higher than 0.5. There is suggestive evidence that the growth of oolite grains is accompanied by an increase in roundness. The three dimensional shape character of the oolite grains suggests that detailed shape interpretations from thin sections may be misleading.

PHYSICS

INVESTIGATION OF A GAMMA-PROTON PROCESS IN BERYLLIUM

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The experiments here described were performed with the 20-Mev betatron at the Los Alamos Scientific Laboratory, New Mexico. The work was done under the direction of William Ogle, with the invaluable assistance of Leon J. Brown.

Many radioactive substances can be produced artificially by bombarding non-radioactive samples with high-energy nuclear particles. In such a reaction, a bombarding particle can be thought of as evicting part of the nucleus of an atom of the sample, and residing there in its place. For example, if a high-energy neutron enters a nucleus of stable nitrogen (atomic weight, 14; atomic number 7), a proton may be emitted, the product being radioactive carbon (atomic weight 14, atomic number 6). Such a reaction is known in the language of nuclear physics as a neutron-proton, or, more simply, an n-p reaction. Reactions are known involving all the elementary particles, both as projectiles and as displaced nucleons. One of the less frequently observed is the process in which a high-energy gamma-ray causes a proton to be evicted from a nucleus. The betatron would seem to be an ideal source of gamma-rays for the observation of such a so-called γ-p process. Its high, easily controlled energies render it very useful, but there is one serious complication. A great many fast neutrons are associated with the beam from the betatron; these induce radioactivities which may easily be confused with or misinterpreted as the results of γ-p processes.

An effort was made to find a substance in the bombardment of which fast-neutron reactions would cause no confusion. Be^9 seemed to be such a substance. The γ-p reaction on this isotope should yield Li^8, which decays with the emission of beta particles with a half-life of 0.88 sec. Except for He^6, which may be produced in several ways and also emits betas with a half-life of 0.8 sec., all other possible reactions yield products which either break up at once or have extremely long half-lives.

A rough experiment indicated that when beryllium is exposed to 20-Mev gamma-rays from the betatron, an activity is induced, and that it has a half-life of the order of one second.

In order to measure the half-life, the beryllium sample was placed against a glass Geiger counter directly in the betatron beam. With this arrangement, counting could begin a few tenths of a second after irradiation, and a high counting rate was achieved. Since the decay was too fast for visual recording of the

data, a timer and the interpolation lights of a scaling circuit were photographed with a moving picture camera. The film could then be projected at a much-reduced rate, and the number of counts per second determined. (The background due to the activity induced in the counter itself of course had to be subtracted.) The half-life thus measured was 0.88 ± 0.03 sec.

Since it is almost certain that some He^6 will be produced, and since it has a half-life almost equal to that measured, it was necessary to be certain that this was not the activity being observed. He^6 is known to decay with the emission of beta particles with a maximum energy of 3.7 Mev, while Li^8 decays with the emission of betas with maximum energy 12 Mev. Thus, a simple absorption measurement should serve to distinguish the two.

Activities induced in an aluminum absorber would have been very troublesome if the sample, absorber, and counter had been held in the beam, as before. Hence, during irradiation the sample (3x3x½ inches in size) was placed at the top of a vertical track in such a way that as soon as the betatron was turned off the sample dropped about 9 inches into position in front of the absorber and counter. As it dropped into place it activated the scaling circuit and a time delay which turned the scaler off at the desired time. In this way the number of counts in the interval between 0.3 and 1.3 seconds after irradiation was measured. This was repeated with many different thicknesses of aluminum absorber. An absorption curve plotted from the data indicated the presence of beta particles of energies up to 13 Mev, showing that Li^8 was present. The presence of He^6 was also indicated by the presence of a low-energy component.

To determine the threshold of the reaction, it was necessary to vary the energy of the radiation from the betatron. In our experiment this was done by changing the time of expansion of the orbit, so that the electrons were made to hit the target at some selected time before reaching their full energy. Sensitive timing circuits were available; so the energy could be varied with considerable accuracy over a large range. The intensity of the beam dropped off sharply as the energy was decreased; so the practical lower limit was about 6 Mev.

Using the dropping technique described previously, a curve of beta activity versus maximum bremstrahlung energy from the betatron was run with 5/16 inch of aluminum (enough to absorb all He^6 betas) between the beryllium and the Geiger tube. At the end of each series of runs at a given energy the betatron yield was measured. A curve of counts per unit of irradiation versus maximum gamma-ray energy indicated a threshold of 18 ± 1 Mev, as compared with a theoretical value of about 17 Mev. With no absorber between the beryllium and the counter, an effect was still observed as low as 6 Mev. This was to be expected, as the threshold for the formation of He^6 is about 3 Mev.

Li^8 decays into Be^8, which immediately splits up into two alpha particles. Since there are no alphas associated with the decay of He^6, the observation of the alpha-particles

themselves should be another method of verifying the presence of Li^8.

Since the alphas expected should have energies of only about 1.6 Mev, their penetrating power is very small. Thus the problem in observing them is to irradiate a large amount of beryllium distributed thinly so that a detectable number of the alphas produced may reach a counter. To get measurable intensities, the sample must be as close to the betatron target as possible. The problem was finally solved with some success by constructing a large wheel of micarta and gluing on one face beryllium flakes in a band of 3 inches average width and 12 inches average radius. This wheel was arranged vertically, immediately in front of the betatron, and connected to a small motor in such a way that it could be rotated at four speeds. The radiations were observed with an alpha-sensitive counter placed at the bottom of the wheel. The counter was at such a distance from the beryllium that only alphas with energies greater than 1.6 Mev could reach it. Numerous tests were made to be sure that the counter was not affected by betas, or by electrical pickup from the betatron, motor, and other apparatus. Shielding was a major problem.

Actual measurements were made by observing visually on an oscillograph the pulses made by alphas. Five-minute runs with betatron yield were alternated with five-minute runs with the betatron off but the wheel still rotating. All runs were made at 20 Mev. A definite, though small, effect was observed (less than 10 counts per minute). To make a rough estimate as to the half-life of the observed activity, the wheel was run at different speeds, thus varying the time elapsed in turning a given sample of beryllium from the beam to the counter. No accurate value of half-life could be determined because of the effect of growth of activity as the beryllium crossed the beam, decay as it passed the counter, and persistence of activity for a time greater than one revolution of the wheel. Approximate corrections were made for these, and the half-life was shown to be about one second, as it should be.

ELECTRONIC AIDS TO CONTROL AND MEASUREMENT

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Many problems in the laboratory involve the measurement of extremely small magnitudes and consequently require delicate and often expensive instruments. Further difficulty is introduced by the fact that such magnitudes often vary rapidly with time, and measuring devices should be capable of following those variations accurately. For many of these measurements, however, it is possible to employ some form of auxiliary equipment which will allow the use of rugged and inexpensive indicating or recording instruments. This paper is a compilation of several such devices, selected for their simplicity, low cost, and utilitarian value.

For the measurement of physical magnitudes other than electrical it is desirable to employ some form of transducing element to convert the magnitude into a proportional electrical signal; this, when amplified and recorded, becomes a record of the physical magnitude. The literature contains much material on simple transducers, therefore only a few general types are listed by broad classes in Table 1.

Table 1.—Simple Transducers

1. Temperature to electrical signal:
   - Thermocouple.
   - Resistance thermometer.
2. Illumination to electrical signal:
   - Photoelectric cell.
3. Movement or dimension to electrical signal:
   - Variable resistance device.
   - Variable inductance device.
   - Variable capacitance device.
   - Variable illumination device.

It should be noted that although electron tubes are used in these circuits, they are used only where they provide the simplest and most satisfactory method. Care has been taken to employ no circuit components which cannot be obtained from any radio parts supplier. Most of the following circuits are operated from the a-c. line; thus there is no cost for special power supplies. No special tricks in construction are required, although ordinary good practice should be observed. The information given here is adequate for duplicating the circuits. Data in the curves are representative of what may be expected, although some variation will naturally be found from one circuit to another. The circuits are recommended not for their novelty but for their utility; and to this end the designs have been simplified to use the minimum number of circuit elements consistent with good performance.

The first circuit to be described is drawn as figure 1. Here one winding of a transformer is placed in series with a load (or an output device or an instrument) and an alternating current source; its ability to pass alternating current is controlled by the potential of the grid of an electron tube across its other winding. Thus a current of several amperes may be controlled by a small applied potential. With the direct-coupled preamplifier

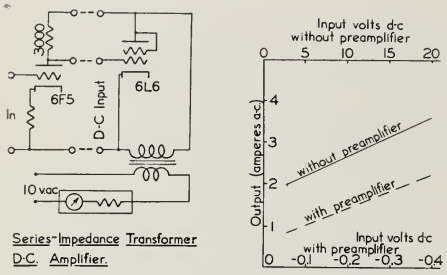

FIG. 1.—Series Impedance Transformer

(shown connected by dashed lines) the control potential may be but a small fraction of a volt. If a direct-current output is desired, a dry-disc rectifier may be added.

Figure 2 shows another device to give relatively large output currents from small input potentials. In this device the cyclic intervals of current flow through a miniature thyratron are controlled by the grid potential. Either a transducing element (i. e., a photocell or a variable resistance) or a second electron tube may be employed in a phase-shift circuit to affect the grid potential. The output of the thyratron tube is pulsating direct current, which may be filtered and applied through a negative feedback circuit to give extremely high stability. In the diagram, however, a transformer and dry-disc rectifier have been introduced into the plate circuit of the thyratron to give many milliamperes of output current at low impedance rather than a few at a potential of several hundred volts.

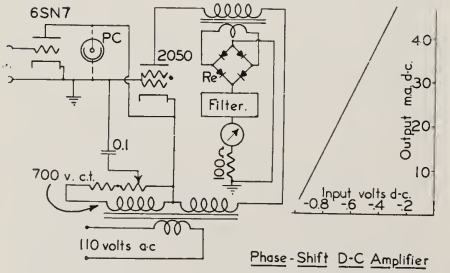

FIG. 2.—Phase-shift Amplifier

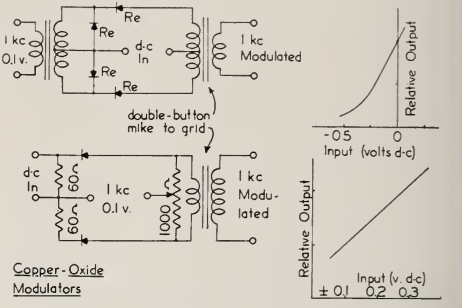

FIG. 3.—Copper-oxide Modulators

The next two circuits, shown in figure 3, may be used to convert the small output of a thermocouple (or any similar potential of a few millivolts) into a current of several milliamperes, easily recorded. An alternating carrier voltage is modulated by the copper-oxide rectifier units, *Re*, as their impedances are changed in response to the direct current flowing through them from the thermocouple. The resulting modulated signal may be amplified to any degree desired and demodulated to give an easily recorded output. Both circuits require a few milliamperes input current at low voltages, unlike the other circuits described, which draw almost no current from their signal sources. The two circuits are not alike, but they perform in much the same manner, as is illustrated by the curves of relative output. It is assumed that ordinarily an amplifier will follow the modulator circuit; it is for this reason that only relative output is shown in the curve.

All of the measuring circuits described in this paper are capable of

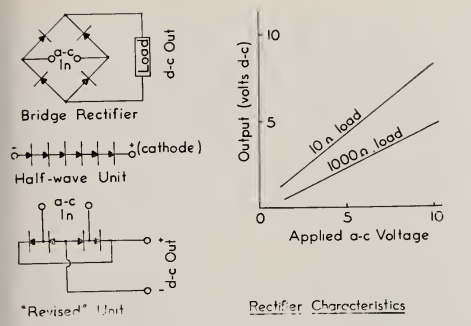

FIG. 4.—Bucking-out Circuits

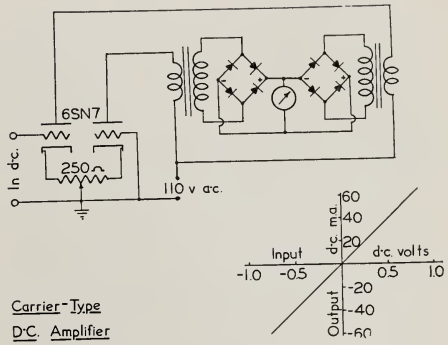

FIG. 5.—Carrier Type Amplifier

following inputs varying at a few cycles per second. In addition, the two circuits shown in figure 3 and the one of figure 5 may be given much more rapid response by increasing the frequency of the carrier voltage. For variations in the measured potential up to about 10 cycles per second the 60-cycle line current may be used; for measuring rapid fluctuations in temperature with a thermocouple, 1,000 cycle carrier supply was used with the circuit of figure 3.

With many of these devices, if the amplifier output is simply rectified for d-c. output, it is often not convenient to adjust the circuit so that the output current becomes zero for a particular input potential. To use the indicating instrument in the most efficient manner it will be desirable to inject a bucking-out current into the output circuit. One convenient method for doing this is shown at the left in figure 4. Here a dry-disc rectifier is supplied with alternating current from an independent source and connected so that its output opposes that from the amplifying device. Adjustment of the bucking-out current is simple, and it is used to establish the zero of the indicating instrument as may be desired. This is often an advantage, particularly with the circuit of figure 1. The circuit at the left is good for large output currents at low voltages; the circuit at the right is better suited to the opposite case.

A circuit basically similar to those of figure 3 but capable of handling more power is presented in figure 5. If the control grids of both triodes are at the same potential, the two plate currents will be equal, and the output of the differencing circuit containing the dry-disc rectifiers will be zero. As the input potential varies, the difference output will vary in proportion. This circuit has sufficient output to actuate an ordinary industrial recording instrument. It is convenient to provide a variable control in the cathode circuit so that individual differences in tubes and rectifiers can be compensated.

It may be helpful to insert at this point a note about the rectifiers used in these circuits. The copper-oxide units used in the modulating circuits are simply small meter rectifiers of the lowest current capacity conveniently obtainable. The rectifiers

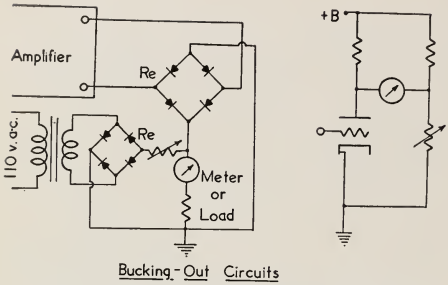

Fig. 6.—Rectifier Characteristics

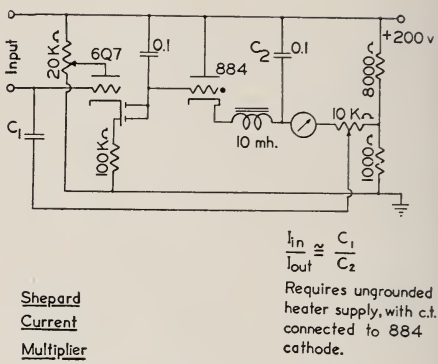

Fig. 7.—Shepard Current Multiplier

used in the output circuits, however, must be capable of handling higher currents and also of withstanding greater back voltages. The small selenium rectifier units now popular for use in household radio repair work have been found suitable for this application. As made, they have either five or six plates connected in series, and they are used as simple half-wave rectifiers; they may easily be disassembled, however, and reassembled to form bridge rectifiers as indicated in the diagrams. The performance curve of figure 6 shows what may be expected of such a "revised" rectifier unit. Ordinary filament transformers (117 volts to 6.3 volts, at 1.5 amp.) have been found completely satisfactory for use as output transformers with these rectifiers; they have been used in these circuits. This is another part of the attempt to simplify the problems of procurement and construction.

The circuit in figure 7 has been termed a "current multiplier" by Frank Shepard, who first disclosed it, and the name describes it perfectly. The feeble input current may be a small fraction of a microampere, from a source of a small fraction of a volt, while the output current is enough to actuate a husky milliameter. The multiplication is controlled by the ratio of capacitors C_1 and C_2. Changes in other components, fluctuations in supply voltages or variations in tube characteristics due to ageing will have negligible effect on the performance of the circuit. In operation, the *6Q7* plate supply is first adjusted by the voltage divider to a value for which the thyratron, *884*, just fails to conduct. If input current is then allowed to flow into capacitor C_1 the circuit will begin a regular series of relaxation oscillations in which the miniature thyratron repeatedly discharges C_2 through the indicating instrument while continually recharging both capacitors from the common power supply.

The last of these circuits, shown in figure 8, is designed to indicate or to measure time intervals. The three neon glow-lamps, *Ne*, are connected in relaxation oscillator circuits containing circuit components so selected that one bulb produces pulses at one-tenth second intervals, one at one-half second, and the third at one-second intervals. Placed side by side and so mounted that their light impinges upon a moving photo-

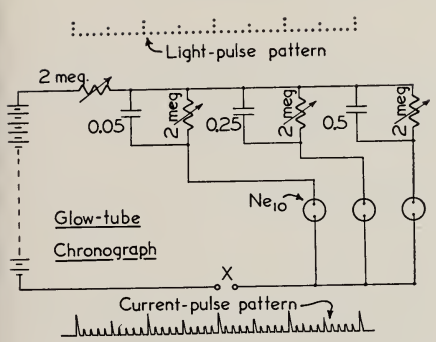

FIG. 8.—Glow-tube Chronograph

graphic film or paper, the device places a time scale on the photographic record like the pattern at the top of figure 8. The current output, taken off at X, may be recorded if desired with some current-sensitive device; its wave-form is like the pattern across the lower part of the figure. Other time scales may be afforded by suitable choice of circuit constants; for the lowest rates it is convenient to employ a small clock-type synchronous motor and a suitable commutator. For those laboratories equipped with seconds clocks a pendulum contact is a simple way of making available timing marks at second intervals only.

The device is capable of quite high accuracy if care is taken in design and in adjustment of the circuits. Because of individual variations in neon bulbs, each circuit must be separately adjusted. Operating current is small and is conveniently supplied by a radio B-battery of about 135 volts. Adjustment for variation in battery voltage is made with the two-megohm rheostat in series with the battery. This also serves to synchronize the pulses at the half-second and full-second intervals. One of the best types of neon bulbs for this use is the one-twenty-fifth watt Type Ne-10 baseless bulb.

With the possible exception of the current multiplier, each of the circuits, when incorporated in a measuring system, must be calibrated by comparison to an instrument whose accuracy is known to be at least that with which the final measurement of the unknown magnitude is to be made. Calibration checks under various conditions will help to detect any lack of stability of circuit components. Line voltage variations must be taken into account or eliminated. Since the performance of the current multiplier depends almost exclusively upon the ratio of magnitude of two circuit elements, knowledge of the value of each will allow the performance to be calculated. A calibration of the device is of value, however, in helping to eliminate whatever error has been incurred in measuring the two capacitors. It must be recognized at the outset that the accuracy of a measurement with one of these devices can never be much better than the accuracy of the indicating instrument used in the output, despite calibration, however often.

In order to secure dependability of measuring systems based on these circuits, every non-essential part has been eliminated and the resulting circuit critically re-examined for possible further simplification to secure maximum reliability. We feel that simplification is to be sought after, for it confers ease of construction and reliability, as well as lower cost.

SIMPLE CIRCUIT FOR MEASURING VARIATIONS IN ELECTRICAL RESISTANCE OF A HUMAN BEING UNDER EMOTIONAL STRESS

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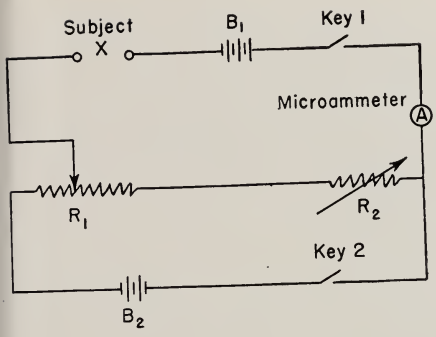
Variations in electrical resistance offered by the body of a human being under different circumstances of physical and mental stress have been known for some time. Darrow[1] in 1934 described a "reflexohmeter" which was improved upon and modified by Lauer and Anderson[2] in 1937. Many years previous to this, the studies of Leonarde Keeler brought forth the instrument known as the "electrocardiograph."

The Lauer instrument was used for several years in measuring the excitability of persons as one of several factors which were thought to be pertinent characteristics of a good automobile driver. The National Reseach Council, as it was organized at that time, together with the American Automobile Association and the National Safety Council used this device for several years. As an index of the intensity of its use, the author applied the Lauer "Responsohmeter" to some 2,300 persons during one summer. In each case, the instrument was balanced to give a null reading with the individual in the circuit. As the individual's tension increased, the electrical resistance was found to decrease, thus upsetting the balance of the circuit. It might be worth noting here that using palm contacts consisting of cups filled with salt water which were inverted, palm-of-the-hand, up, yield resistances which vary among individuals from about 4,000 ohms to nearly 30,000 ohms, when the cup diameter is approximately 4 centimeters. Under such minor excitations as the noise produced by slapping a desk top sharply with a ruler (behind the testee's back), resistance variations of the order of 2 percent may be expected. If the subject is "nervous," or if the particular stimulus carries great significance in the subject's pattern of evaluations, variations as high as 16 percent of the resistance may be found. Thus, a stenographer who is afraid of her dictatorial boss will show more response to the sound of a buzzer than she will show to a much louder automobile horn.

The principle of the device is that of the simple potentiometer. Two cells of comparable e.m.f. or voltage are connected in opposition to each other, each through variable resistances. The person tested is one of these resistances. Variations in his resistance occur as his perspiration varies. A time lag of from 2 to 7 seconds is observed between the stimulus and the maximum ammeter reading. A new setting or resistance level is used after each stimulus. These new settings are found after the resistance seems to stabilize which is usually a matter of a minute or two after the stimulus is given.



Sometimes a subject professes to be afraid of electrical wires. Of course, the total amount of "electricity" passed through the subject is less than that which redistributes itself in the process of combing the hair. A colleague suggests that "potentials" instead of resistances are responsible for the readings. Failures to date to find any polarity effects make the concepts of "potentials" difficult to accept.

To make the device readily portable, a simple microammeter was substituted for the galvanometer of the convential potentiometer circuit. A microammeter whose range is 0-30 mu when used with 4½ volts and 20,000 ohm resistances has proved to be usable.

Assembled into a portable unit, this becomes an instrument which is useful in motivating students who have occasion to study the potentiometer. It is useful as a means of measuring excitability of persons in unexpected situations—such as the study of characteristics of automobile drivers by Lauer and others. The statement has been made that no satisfactory way of measuring pain has been devised. Perhaps this device may be a step in that direction—at least it can measure the response to pain. It provides a simple means of studying some of the electro-chemical phenomena of human reactions without requiring a puncture or abrasion of the skin for contacts.

Since some interesting perturbations of the ammeter needle have been observed during the early stages of reponse to a stimulus, two proposals have been made for further study. One involves connection with an oscilloscope to study possible oscillotory character of the variations in resistance—or of potentials, if so they be. The other proposal is to incorporate a push-pull amplifier or similar device into the circuit to give greater sensitivity.

A popular usage of this device should not be totally neglected. While reference was made to Keeler at the beginning, it is not the intention to indicate that such a potentiometer circuit alone would be a suitable lie detector. However, the concern which the ordinary individual bears toward the winning of any game will cause enough increase in his perspiration at the palms to readily detect the little "white lie" when he denies his correct age, or similar incident. The usual procedure at social and service clubs is to instruct a subject to choose one number between one and ten. Then he is instructed to deny all suggested numbers. Try to beat it!

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[1] C. W. Darrow, The reflexohmeter (pocket type), *J. Gen. Psychol.*, 10, 1934, 238-239.

[2] Alvah R. Lauer and Donald E. Anderson, *Am. Jour. of Psychol.* 51:1, Jan. 1938, 156-159.

SOCIOLOGY

THE STRUCTURE AND INSTITUTIONALIZATION OF A PROTEST GROUP*

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Wheaton College, Wheaton

This is a study in the sociology of a protest group. The particular group under study is the Orthodox Presbyterian Church—a religious group which seceded from the Presbyterian Church in the United States in 1936.

In opposing the alleged doctrinal defection in the parent body, some of the dissidents set up an independent mission board for which they solicited funds. By being stewards of a mission enterprise which would send only doctrinally orthodox missionaries to the field, the dissidents ran afoul of ecclesiastical law and were suspended from the ministry of the Presbyterian Church. This nuclear group was joined by other ministers and parishoners of like persuasion. Shortly after its inception, the newly formed church had seventy-five member ministers under its jurisdiction and nine Presbyteries had been erected. They chose to be known as the Presbyterian Church of America.

In the ten years of their existence, the "come-outers" have encountered much rough terrain. Their leader, J. Gresham Machen, died suddenly six months after the first General Assembly in 1936. In the second General Assembly held in November of 1936, a doctrinal dispute developed on premillenarianism versus amillenarianism. This cleavage in the pristine harmony of the new group was deepened when the disputants took opposite sides on two additional thorny questions—Christian liberty in regards to alcoholic beverage consumption, and the "independency" of the Independent Board for Presbyterian Foreign Missionaries. In 1937, as a result of these differences, a sizable group of ministers and elders withdrew from the new church. A third blow came as a result of a complaint by the Presbyterian Church in the United States asking the court to enjoin the group from using the name "Presbyterian Church of America" on the grounds of similarity. The court decided in favor of the plaintiff church. Therefore, in 1939, the present name of Orthodox Presbyterian Church was adopted.

The Orthodox Presbyterian Church has shown some growth. The number of ministers has increased from seventy-five to one hundred and two in ten years. The membership has grown from 4225 in 1938 to 7555 in 1946. Fourteen new comgregations have been added.

The primary focus of this study is the institutionalization of the protest group. It is well known that radical protest groups do not remain as such, but gradually lose their

* This paper is an abridgement of an unpublished Master's Essay submitted to Columbia University in June 1948

rough edges until they resemble the more orthodox religious, political, or economic groups in society. What does sociology have to say about such phenomena?

Sociology provides several tools that give insight into the problem. The first concept is that of group structure. Although the dynamic social process of group structure is quite ephemeral, there are "certain of the relationships set up between the members which tend to assume a more permanent character"[1] as the group emerges. This makes possible a static view—somewhat of a cross-sectional view at any one moment of time—which captures the persistent relationships of the group. These relatively permanent relationships "provide the structure in terms of which the more evanescent processes of group interaction are carried on."[2] These more persistent relationships have been termed institutions. For example, MacIver sees them as products or embodiments of the process of social relations. Institutions are "forms or conditions of procedure characteristic of group activity."[3] Therefore, if one examines the early institutions in the life of the Orthodox Presbyterian Church, one has a base-line against which one can compare the increasing complexity and rigidity of structure through the years. This increasing complexity and rigidity is one major facet of institutionalization. Before looking at the structure it is necessary to point out the general character of the protest.

The locus of the protest was in that religious field of expression known as doctrine. The fields of ritual and organization were left alone. Usually secession originates as a protest against conditions in one of these three fields. No significant protest was launched by the dissatisfied group against the social policy of the church. The bulk of the protestations were in the field of doctrine. This fact, combined with the total lack of protest in the realm of organization, goes a long way in explaining the sociological consequences of the secession. The usual types of group organization open to seceding groups are, according to Wach, (1) the independent organization in which the distinctive feature is the adoption of its own principle of organization, and (2) the sect.[4] That the independent organization was chosen was almost inevitable because of the locus of the protest.

One would hardly expect that a protest group with no complaint against the organization of the mother church would turn about face and discard existing bonds for new, strange lineaments of organization. Those who protest against the formal aspects of organized religion frequently consider all constitution, hierarchy, law, discipline, priesthood, or ministry to be not only mistakes but even apostasy and sin.[5] Stating it in slightly different terms, one might say that rationality is highly correlated with more complex organization, and that experience of the mystical type is closely related with the informal, less complex type of organization.

If the transition from sect to church is conceived as a continuum,

[1] Coyle, G., *Social Process in Organized Groups*, (R. R. Smith, Inc., New York, 1930), p. 78.
[2] Ibid., p. 78.
[3] *Society*. (Rinehart & Co., 1937), p. 14.
[4] *Sociology of Religion*, (Chicago: Univ. of Chicago Press, 1944), p. 194.
[5] *Ibid.*, p. 193.

then one might say that the organization of the newly formed Orthodox Presbyterian Church enters approximately at the center of the continuum. The reason for this exceptional behavior pattern is, as stated previously, the sociological consequence of the locus of protest, an emphasis in the field of religious expression known as doctrine, and corresponding lack of emphasis on organization as fields of dispute.

But what is the picture of the structure of the group in its earliest years? By borrowing in part a structural scheme suggested by Woodward and Sutherland,[6] we can outline the major aspects, using them as rubrics under which the social processes of the Orthodox Presbyterian Church can be classified. They are: A plan for the division of responsibility, a plan for procural and initiation of new members, a plan for the standardization of behavior, and a plan for maintaining group status.

The first aspect of group structure, a plan for division of responsibility, reflects the well crystallized attitude of the new group toward formal organization. Immediately upon constituting themselves a General Assembly, four committees were established. Within the year (1936) these committees were in operation. The major interests of the group were reflected in these committees. The committee on the constitution is the embodiment of the plan for the division of authority. Within a few months this committee presented a confession of faith, a form of government, a book of discipline, and a directory for the worship of God to the General Assembly. By accepting almost in toto the constitution of its parent body, the Orthodox Presbyterian Chuch came into being with well established ideas—evidencing what Wach terms a maximum type of organization.[7] Not only setting up committees, but the substantive concerns of those committees indicate a plan for division of responsibility. Examples would be the constitution and erection of presbyteries.

The second aspect of the group structure of the new church is a plan for new members. Both the committee on Christian Education and that on Home Missions and Church Extension reflect this interest. The church shows first regard for setting up the requirements of its spiritual leaders. Ensuring doctrinal orthodoxy is consonant with the protest against doctrinal defection. And group status is more easily attained if, as was noted in the minutes of the first General Assembly, the church does not "trust the ministry to weak and ignorant men. . . ."[8] The early professionalization of leadership in the Orthodox Presbyterian Church is offered here as evidence that this religious protest group entered its life with its means to ends well stabilized. Professional leaders tending to form a bureaucracy reflect no small amount of institutionalization. It is interesting to note that the danger of professionalized leadership is not the only problem resulting from rigid requirements. There is, in addition, the concomitant problem of procuring leaders and followers when the standards are high. Per-

[6] *Introductory Sociology,* (Lippincott, 1940), p. 299.

[7] *Sociology of Religion,* (Chicago, Univ. of Chicago Press, 1944), p. 145.

[8] *Op. cit., p.* 18.

haps this explains the dual program enumerated by the Christian Education Committee when it recommended both noetic and experiential aims. In fact, the church preaches realization and avowal of covenant blessings to the children of believers, but "saving faith" (which is experiential) to non-covenant subjects. In the words of the committee, "We must place before even the command to evangelize the lost, this prior responsibility of bringing up the children of the church in the nurture and admonition of the Lord."[9] It is this last persuasion that gives the new group a modicum of the "church" type of organization as stated by Max Weber who pointed out that, "It is (the Church's) character as a compulsory association, particularly the fact that one becomes a member . . . by birth, which distinguishes a church from a sect."[10]

The third element of group structure—a plan for the standardization of behavior—has two modes[11] which are control by sanction and control by socialization. Sanctions, which are external to the personality, take place in several areas. These areas are belief (requiring agreement with the Westminster Confession of Faith), form of government, discipline, and worship. The mode of control which is internalized by educative processes is seen in the Orthodox Presbyterian Church by the persistent efforts in supervising Sunday School material, the study of the Bible, the training of lay personnel as church workers, supporting Westminster Theological Seminary, and the formation of Christian Day schools.

A plan for maintaining group status is the fourth structural element. By striking out hard against "wickedness in high places" the dissidents are catapulted from the sequestering matrix of the parent church. The uneasy position of a new minority group upsets individual statuses. For the Orthodox Presbyterian Church it was a matter of reiterated opposition to the parent church and a reinvesting of its ministers "in good and regular standing with all rights, privileges, and active duties pertaining to lawfully ordained ministers."[12] Consequently, the familiar pattern of out-group hostility coupled with inner-group loyalty characterizes the early life of the protest group. Through the committee on Home Missions and Church Extension, the church sought to express its status when it fought a legal battle with the parent church over retention of its original name. Thus we see again that the Orthodox Presbyterian Church enters group life with definite plans for maintaining group status.

We turn now from the synchronic picture of group structure in order to view the group as it functioned from 1936 to 1946. The concept of institutionalization now becomes the major focus. Institutionalization has been defined as that social process wherein the initial aim or original ethic of a group is gradually displaced by the concern for the organization in itself. The means

[9] Minutes of 12th General Assembly of Orthodox Pres. Church, p. 44.

[10] Parsons, T., *M. Weber: Theory of Social and Economic Organization* (New York: Oxford Univ. Press, 1947), p. 157.

[11] Landis, P., *Social Control* (Chicago, Lippincott Co., 1939), p. 335.

[12] Minutes of 1st General Assembly of Pres. Church of America, 1936, p. 12.

whereby the group pursues its ends gradually occupy the group's concern more than the original ends.

This process cannot be seen by a simple extrapolation of the means of the group from the totality of its life processes, with the naive hope of watching the means or structure become incrusted, complex, spotlighted, more important, etc. Rather, the very burning issues which absorb the members of the Orthodox Presbyterian Church from day to day must be considered as the backdrop against which the persistent structural aspects become apparent. For example, the plan for the standardization of behavior as an aspect of group structure becomes increasingly more important as the strong minority bid for "eschatological freedom."

These decision situations are the dynamics of the process of institutionalization. Upon these decisions rests the process of institutionalization. In fact, the process may be accelerated, decelerated, or thwarted completely. There is no ineluctable destiny for the group once it is organized. However, the process of institutionalization cannot, therefore, be minimized. A decision making for or warring against institutionalization is made only at a cost. There arises a dilemma—a peculiarly bothersome one for religious groups. It is known as "the dilemma of the churches."

The formulation of the concepts in the dilemma of the churches is the work of many sociologists. Troeltsch, Max Weber, Von Wiese, MacIver, and Yinger have dealt with the phenomenon. The dilemma of the churches is that of choosing between two ideal types of response. They are at opposite ends of a continuum. The sect type response is that wherein the group in the struggle for power in society refuses to compromise its ethic, purpose, or value and thus withdraws. By withdrawing from society it keeps its ethic pure but loses influence, except as a critic. The church type response is that wherein the group compromises its ethic to gain influence and thus moves toward identification with society. By gaining power it has lost the strength which derives from a pure ethic. This dilemma, obviously, is not restricted to religious groups. Wherever a group is impelled by an urgent value, this dilemma will arise.

This discussion of social organization becomes meaningful, however, only when we ask what is behind the choices resulting in a church type response or a sect type response. The root of the sect or church type responses is in the dual nature of a religious group. It is both suprasocial and social. The achievement of the values of a religion demands some kind of power over often recalcitrant human beings, and thus the religious expression seeks embodiment in organization. This organization may, however, defeat its original purpose by adopting methods used by secular organizations which are made necessary by the relative lack of a strong religious interest in most individuals. There is embodied in the religious institutions a manifestation of two contradictory sets of values, one clustering around the religious idea, the other centering in the secular power of the institution. Faced with the clamor of con-

flicting powers the group must attempt adjustment. And such an adjustment rides the horns of a dilemma.

The church type of response leads to identification of the group with society, with attendant support of the *status quo* of the social structure. The sect type response leads to withdrawal from society with a consequent indifference or hostility to the *status quo*. Transition from lack of support of the *status quo* to support of *status quo* is well known to sociologists as the conflict—accommodation cycle.

The process of institutionalization is seen in the transition from the sect to the church. It is well to remember that not all religious organizations begin with a sect. Some, like the Orthodox Presbyterian Church, have both sectarian and church type elements. Hence, the problem before us is to ascertain the direction of the Orthodox Presbyterian Church.

The admixture of sect and church elements provides the nuclei around which are clustered protagonists. Their role in the growing cleavage in the church highlights the sect-church dilemma. Beginning with the strife over eschatological freedom the Orthodox Presbyterian Church faced the dilemma.

Eschatological freedom was one of a triumvirate of disagreements that occurred nearly simultaneously. When the issue of Christian liberty in regards to alcoholic beverages, and the "independency" of the independent Board for Presbyterian Foreign Mission were added, there was formed a tight weld of interests. To have relaxed the general attitude toward premillenarianism could have meant inclusion of more prospective members. To have changed the constitution in regard to Christian liberty could have meant inclusion of more people favoring the separated or unwordly life. To have condoned the independency of the Mission Board could have meant inclusion of some men not wholly responsible to the Church. The dilemma was one of relaxing the standards to gain members and power, and by so doing, losing some of the purity of the original ethic. Many felt it might be the opening wedge of modernism. The majority chose to retain the standards without change. A minority of 29 ministers resigned.

Such a sect type response may have been an initial rash act of those untutored in the danger. At any rate, it is perhaps worthy of note that the next major problem that arose was handled in a much more sophisticated manner. When the opinion began to crystallize in 1939 that members of oath-bound societies should not become members of the church, the church deftly handled the matter by referring it to committees for study. Nine years later (1948) the issue was still buried in committee study.

In 1941 a vexing problem arose which seems to be the forerunner of the present cleavage in the church in which adumbrated sect and church type nuclear groups began to form. Here we see becoming explicit for the first time the actual struggle of the church for power in society. It was determined that a Committee of Nine be elected to "study the relationship of the Orthodox Presbyter-

ian Church to society in general, and to other ecclesiastical bodies in general, with a view to bringing recommendations suggesting ways and means whereby the message and methods of our church may be better implemented to meet the needs of this generation and the Orthodox Presbyterian Church may have an increasing area of influence and make a greater impact on life today."[13] Disputation arose over the best way to implement such a goal. A minority group recommended "emphasis upon the vigorous proclamation of our distinctive faith rather than upon cooperation with other churches."[14] Here we see a characteristic sect type response to the social milieu.

It would take more time than we have available to describe in detail these various eruptions and their development. We can do no more than touch the highlights. A highlight which is ancillary to the problem faced by the Committee of Nine was seen in one of the ideas which grew out of their deliberation. Some of the church leaders wanted to establish a Christian University supported by Christians throughout the land. Orthodox Presbyterian Churchmen were in the forefront of the movement. They went as far as buying an expensive estate near Philadelphia only to find too few Christians willing to support the idea. The reason given was that the board of directors tried so hard to avoid heterodoxy in their detailed Calvinistic views that they could not compel interest in the American people to bring in the necessary money. As a result of this uncompromising sect type approach, the idea never caught fire. The estate is now a white elephant.

Those making the sect type response in regard to how to deal with society soon found themselves together in a doctrinal dispute centering around a certain Dr. Clark. The rationalism into which Dr. Clark was allegedly slipping was of course an indication to those of the minority right wing—or sect type—that compromise was imminent. It did not help matters when Dr. Clark became a leader in his group for close cooperation with other evangelical churches in an ecclesiastical organization. At the close of this study in 1946 this had become the central point of the dispute. Inclusivists desiring cooperation were called "left-wingers," and those who were exclusivists were being called "right-wingers." Overtones of political ideology are also becoming apparent as the left-wingers, although largely conservative politically, have become actionists. Now we see the increasing pressure in the church to move toward the church type response, in which change is demanded.

Such polarization as seems to be in process is not near completion. There are still some members who are in flux. The lines are not as yet drawn too clearly. What are seen are syndromes. The way these latest problems are dealt with will reveal which direction the church chooses to go. Should the church type response predominate, the protest group will lose much of its original character as it becomes more institutionalized. Should the sect type response predominate, the group seems destined to live in quite

[13] Minutes of 8th General Assembly of Orthodox Pres. Church, p. 24.
[14] Minutes of 9th General Assembly of Orthodox Pres. Church, p. 32.

a bit of tension because of its highly articulated organization which precludes complete withdrawal from present entangling forces.

If the sect-church dilemma provides the dynamics of institutionalization, then the mechanics are to be seen in such accoutrements as growing structural complexity, increasing accommodation to out-groups, and a decrease in resort to charismatic authority. The dilemma of the Orthodox Presbyterian Church, whether to follow the sect type pressure group or the church type pressure group, has resulted in a cleavage. The cleavage in turn has concomitants.

The first concomitant of cleavage under discussion is structural complexity. The growing proliferation of the means or ways of proceeding of an organization has been called the process of institutionalization. It is proposed that such a phenomenon results in part from the growing attempt on the part of the group to settle the dissension. When the function of the group has added to it the problems of the sect-church dilemma, there is also an added element of structure. The evidence adduced in that area of the division of responsibility is the numerous changes in the form of government, changes in the rules of debate and decorum, and a proliferation of committees—from four in 1936 to 16 in 1946. Differentiation of structure also took place in the plan for new members as the church attempted to clarify requirements and recruitment procedures, as witness the concern of committee on oath-bound societies, and the committee on local evangelism. Whether to reach the lost first or the covenant youth of the church was the issue. By deciding to concentrate on the children of the church the work of the Christian Education committee was set up. Thus in that area of standardization of behavior there is also complexity. The budget increased from $750 in 1940 to $12,420 in 1946 for the committee on Christian Education. Its expenditure list increased in the same period from six items to seventeen. The last element of group structure, maintaining group status, takes an interesting turn. Its complexity is developed in the increased work of the committee on Home Missions and Church Extension which had a budget of $7,400 in 1936 and $58,362 in 1946. However, the focus of the committee was not on battling outside groups. Rather, emphasis on internal machinery, a preoccupation in building itself rather than opposing out-groups.

The second concomitant of cleavage is accommodation to out-groups What we see is a toleration of many out-groups. Opinions are in flux in the church, and the growing challenge to the early right-wing leadership illustrates the demand for "united action on the part of Bible believers . . . Our world and life view demands that our isolation be ended."[15] The exclusivists, with sect type response resist any change of original viewpoint, fearing modernist inroads. The inclusivists, with church type response, press for some compromise because they fear the church may become ingrown. Consequently, with dissension internalized, there is subsequent forgetting of enemy out-groups. The

[15] Minutes of 12th General Assembly of Orthodox Pres. Church, p. 65.

paradox is that by pressing for accommodation, the inclusivist group has drawn the attention of the exclusivist group to the strife in the church, with the consequent forgetting of conflict with others. The pressure for wider accommodation is seen in the inclusivist's drive for cooperation with other churches. As they put it, "We are faced with a life and death struggle which compels us to join the American Council of Christian Churches or stay on the side lines and argue among ourselves with distinct possibility of either perishing or existing as a harmless and freakish sect."[16] The social conditions which act as determinants for these sect-church dilemmas are nowhere more clearly seen. In the minority's opinion ". . . the social and moral questions of society demand united action on the part of Bible believers."[17]

Parallel with inclusivist drives for more amicable relations with some out-groups is the development of numerous committees appointed in order to keep the church functioning smoothly—an indication of the focus of the group.

Because man's religion has a social component it is subject to the social processes. Though not fully clear in the Orthodox Presbyterian Church, there is yet evident the accommodation process as a concomitant of cleavage.

A final word on the concomitants of cleavage concerns the routinization of charismatic authority. It is obvious that the prolix cleavage is an indication that the problem was not solvable by recourse to the Scriptures—a charismatic authority. The question then arises—to what authority are the two groups appealing? The answer is that both traditional and rational types of authority (to use Weber's concepts) are invoked; and, that such recourse indicates the growing routinization of charisma. The life of the church is not only dependent on the vitality of charisma; it is also dependent on the traditional and rational authority to which it now turns to settle the dispute. Ultimately the supra-social may be encrusted by the social. At present, the charismatic authority is strong, but relegated to a secondary position as the church is plagued with the dilemma. Illustration for this point is seen first in the work of the committee on Texts and Proof Texts which cautions that rational action is necessary to answer many questions left unanswered by the Scriptures. That rational action —or "light of nature"—includes such mundane social patterns as traditional authority is abundantly clear from the Clark case. This case was the crux of the sect-church dilemma as the group faced it in 1944, and the scurrying of both sides to find precedents for their views indicated the prevalence of traditional authority. The complainants referred to Hodge, Calvin, Warfield, Thornwell, Charnock, and Bavinck as reformed theologians with whom Dr. Clark was out of step. Since 1944 there has been a notable decrease in appeals to theological heroes of the reformed faith as each side issues papers which are of necessity more rational. Znaniecki, in his work entitled *The Social Role of the Man of Knowledge*, has described how dis-

[16] *Ibid.*, p. 64.
[17] *Ibid.*, p. 65.

putation among the sacred leaders involves a recourse to rational argumentation which is inimical to charismatic authority.

Conclusion of the study of the protest group leaves us with the following hypothesis: the phenomenon of institutionalization is in large part the result of decision situations in the sect-church dilemma which in turn have the unpurposed concomitants of structural complexity, accommodation to out-groups, and routinization of charisma.

SOUTHERN ILLINOIS—A CULTURAL AREA

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Introduction

In the southern 31 counties of Illinois certain economic, social, and cultural traits and complexes exist which tend to differentiate the area from the other parts of the State. Geographic factors such as soil type, climatic conditions, and topography, along with the fact that it is bounded on three sides by important rivers, give it additional distinctiveness. Also, it has what might be considered a cultural center in Southern Illinois University located at Carbondale in Jackson County. This university, being the only accredited university in the southern third of Illinois, serves as a focal point for advanced education. The 31 counties included in the analysis presented here were selected on the basis that they regularly supply students to the university and are considered by the administration of the university as being in its sphere.

Although many definitions of a cultural area have been presented, the thesis of this paper is that the area analyzed complies with the definition given by Duncan.[1] He defines a cultural area or region "as a locality characterized by the prevalence of dominant cultural traits and complexes which form a common pattern of life. Such an area must have a center, or focal point, where the concentration of the characteristics becomes relatively fixed."

The analysis is still in process. To date it has been limited in scope, for the most part, to secondary source materials. It is recognized that a complete analysis must include cultural factors that do not lend themselves to quantitative methods. Since it has not been possible to date to include these cultural factors, this paper is presented in the form of a progress report. The information here presented, incomplete though it may be, indicates the presence of cultural factors which confirm one another and consistently reveal a cultural area.

It should be pointed out that before developing programs for the correction of social and economic problems confronting given geographic areas, it is essential the culture of the area be analyzed. Areas such as the one found in the southernmost part of Illinois contain problems directly related to the culture, to the social situations, and to the economic conditions found.[2] Only by determining the interplay of these cultural elements and social and economic factors, along with the influences they exert, can a sound program for their improvement be developed.

Analysis of the Area

A number of indices are being used in the analysis to determine

[1] Duncan. O. D., "Southwest, a Cultural Area in Evolution," *Southwest Review*, Vol. 27, No. 4, Summer 1942, p. 391.

[2] Please accept the writer's opinion that the existence of problems in the area does not necessarily mean that this is a problem area. Every area has its problems.

FIG. 1.—Infant deaths per 1,000 live births, 1942-1944.

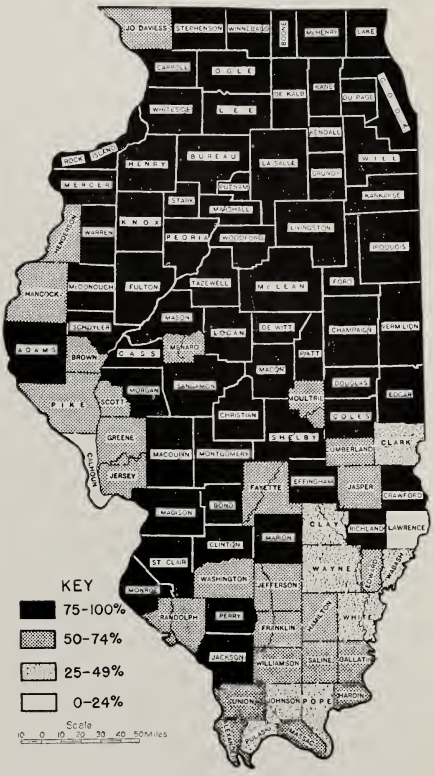

FIG. 2.—Percent of births in hospitals, 1945.

whether a cultural area exists. Ten of these indices will be presented in this paper.[3]

First, let us consider three economic factors that have a close relationship and indicate distinct differences between this area and other parts of the State. The per capita assessed valuation in the southern 31 counties was $1969 in 1945 compared to $2416 for the State as a whole. Only six counties in the area had a per capita assessed valuation above the average for Illinois. The lowest county and nine of the ten lowest counties of the State were found in the area. The average value of homes for Southern Illinois in 1940 was $1323 as compared with $3120 for the State as a whole. Only two counties, and these were different counties from the exceptions referred to in discussing the previous factor, had an average valuation of $2000 and over. The rate of dependency upon the public aid programs was high for Southern Illinois, where in January, 1946, 51.16 persons per 1000 population received assistance. This was nearly twice the rate for the State of Illinois which was 28.58 per 1000 popula-

[3] The sources used for these indices were:
a. Sixteenth Census of the U. S. Population; Second series, 1940.
b. The Illinois Hospital Survey and Plan, Illinois Department of Public Health, July 1, 1947.

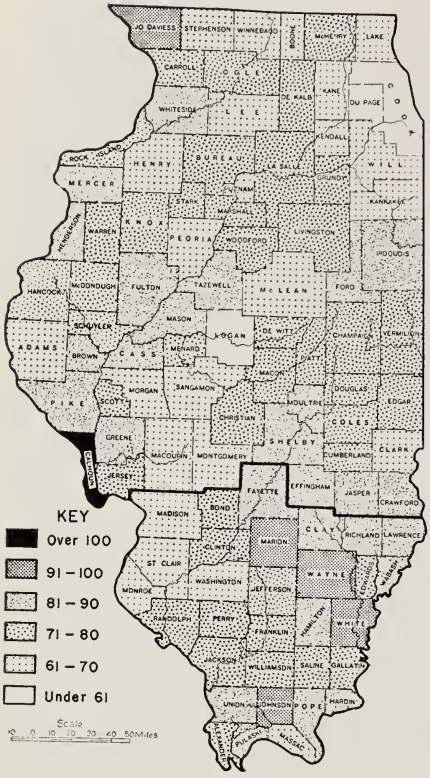

FIG. 3.—Live births per 1,000 females, 15-44 years, 1940.

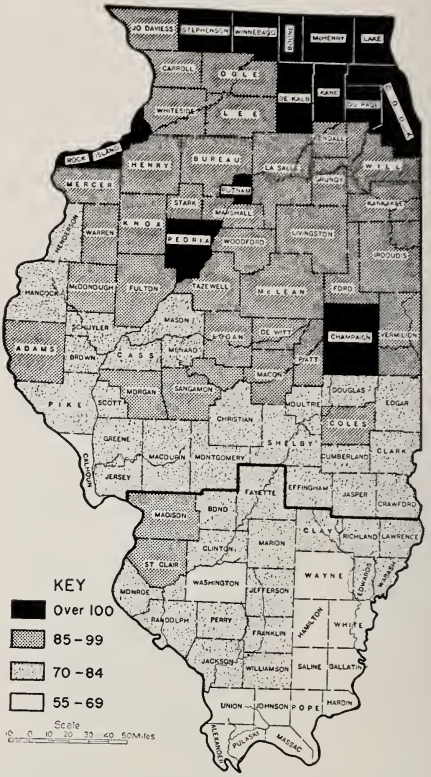

FIG. 4.—Average of ten standard-of-living measures.

tion. Here again, two counties were in the lowest one-fourth of the counties of the State and neither of these two counties were among those listed as exceptions to the low status for valuation of homes or per capita assessed valuation, above.

The educational attainment of the population of the area again indicates a low level of attainment. The proportion of persons 25 years of age and over having completed six or more years of school in 1940 shows that Southern Illinois had just under 75 percent whereas the State as a whole had 81.3 percent Other indices, such as the average year of school completed by the population, show a similar pattern for the Southern Illinois area.

As might be expected, where economic conditions are relatively low the percentage of deaths occurring in hospitals in 1945 is also low. The same thing applies to the percentage of births in hospitals in 1945. A noticeable proportion of the population were unable to go to the hospital to die or to be born.

The infant death rate is also high in this area where we find a rate of 47.4 infant deaths per 1000 live births in the period of 1931-1944 compared to 33.1 for the State of Illinois (fig. 1). One interesting aspect of this is that as the per-

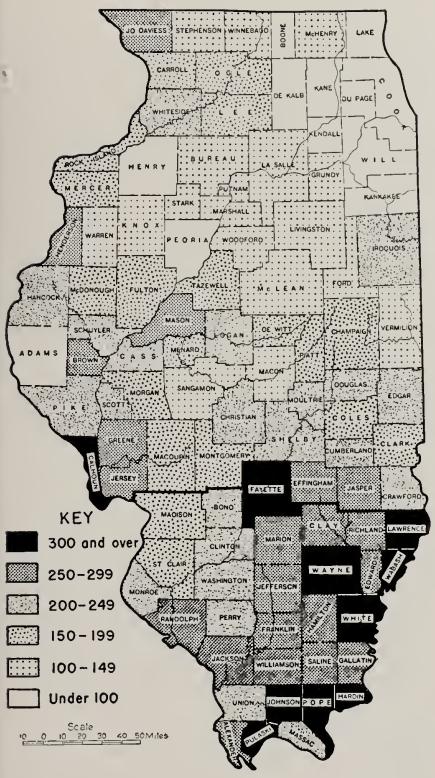

FIG. 5.—Total sum of ranks of five factors.

centage of births occurring in hospitals increases the infant death rate decreases (fig. 2). The live births per 1000 females 15-44 years of age in 1940 was also relatively high (fig. 3). In this instance the highest county falls outside the Southern Illinois area. With the exception of five of these 31 counties, all the counties in the area fall within the four highest ranks of counties in the State, namely, those having more than 70 live births per 1000 females, 15-44 years of age in 1940.

The average of 10 standard-of-living measures shows that the Southern Illinois area in general is below the rest of the State (fig. 4). With the exception of Calhoun County, which adjoins this area to the northwest, and may have to be considered a part of the same cultural pattern, all of the lowest counties in the State are found in the Southern Illinois area.

Summary and Conclusion

In order to summarize the findings to date, five factors were selected as representatives of the many factors being examined in the study (fig. 5). These were: live births per 1000 females, 15-44 years of age, in 1940; deaths per 1000 population, 1942-1944; percent of births in hospitals to total births in 1942; infant deaths per 1000 live births, 1942-1944; and the average of ten standard-of-living measures. All counties of Illinois were ranked according to each factor and the sum of these ranks computed. These sums of ranks were again used as a final basis for ranking the counties.

TABLE 1.—Distribution of Counties According to Sum of Ranks of Five Factors

Sum of ranks	Counties of Illinois	Counties of Southern Illinois
300 and over	10	9
250-299	20	12
200-249	22	8
150-199	23	2
100-149	15	0
Under 100	12	0
Total	102	31

The counties were distributed as shown in table 1. Of the ranks of all counties, the southern area had nine of the ten lowest counties and

all but two of the thirty-one in the lowest three classes of ranks. It should be noted that a high sum of ranks indicates an unfavorable condition. In assembling the ranks to secure the over-all figures, the fertility factor was reversed since high birth rates are usually associated with rural cultural situations and with the types of factors being used to delineate in this study. The two highest ranking counties of the area were St. Clair and Madison which contain the urban center of East St. Louis and are in the metropolitan area of St. Louis.

Certain counties on the periphery, particularly Calhoun, do reflect some of the same traits as those found in the Southern Illinois area. However, until further investigation warrants a change, it seems advisable to hold to the original 31 counties. This is especially true when nonquantitative factors are considered. For example, the people of this area attach a name, "Greater Egypt," to the area and have a feeling of belonging to it. Certain word usages and political concepts seem to distinguish the area. These are in process of being analyzed and preliminary research lends weight to the present delineation.

It would seem to follow then that a cultural area exists, including the southernmost 31 counties. Only after careful analysis of the conditions, and, of course, with the prerequisite that an objective, scientific point of view be adopted, can adequate plans be developed for retaining the desirable elements of the culture and changing the undesirable.

ZOOLOGY

CHANGING FISH POPULATIONS AS AN INDEX TO POLLUTION AND SOIL EROSION†

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It is a fact well known to any student of ichthyology that there has been a profound change in the character of the fish populations of our lakes and streams within the last half century. Even the layman knows that the pan and game fishes are not as common, and the rough fishes, notably the carp, have prospered greatly in this span of years. There are numerous references to this trend in the literature, and it is not necessary to cite authors to establish this contention.

It is equally well known, in a general way, that pollution has unfavorable effects on fish life, and many states have laws prohibiting the pollution of waters based on the principle that fish are killed by pollution. Wisconsin has a law which places the penalty for pollution on a "so-much-per-fish" basis and different species are given different values. Most states have some degree of so-called legal control of pollution based on this general principle.

There is at least one brief paper (Trautman, 1939) dealing with the effect of man-made modifications upon a local fish fauna in which factors other than pollution are considered.

In spite of all this there has not, to this writer's knowledge, yet been any attempt to evaluate the degree of pollution, or of soil erosion, by a survey of the changing character of fish populations.

Hubbs (1933) and others have directed attention to the fact that pollution, from the point of view of destruction of fish life, cannot be measured by averages or other arbitrary figures, since one exceptionally unfavorable day is all that is necessary to kill desirable fish in great numbers, and the "once in a lifetime" occurrence may be exactly that so far as the fishes are concerned. It isn't necessary to kill a fish but once to make sure that it is dead.

The point being made here is that statistical averages, tabulations of dissolved oxygen, abundance of plankton, effect of pollution upon invertebrates, and all the other limnological data that have been collected regarding pollution is meaningless until it is translated into information dealing with the effects upon the fish population. The logical place to go for that information is not to limnological surveys of elaborate design, but directly to a consideration of what has actually happened to the fishes. If the other data help in understanding why the changes have taken place, well and good, but the bare fact that the changes in the fish population have occurred and are the result of pol-

†Paper presented at the 1948 Annual Meeting of the Illinois State Academy of Science.
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lution is the all-important and significant point which has too frequently been overlooked.

In much of the water of the Mississippi Valley, as elsewhere, there is a "carp problem." It has been this writer's privilege to work on the infamous "carp problem" of the Madison lakes in Wisconsin. The fishermen there have been greatly alarmed over the tremendous increase of the carp in the lower lakes of the Madison chain, an increase which has taken place at the obvious expense of the more desirable species, and there has been much flurry and fuss made over the situation. At the same time the people of this area have been greatly concerned over an "odor nuisance" on the Madison lakes, and this latter problem has created such public demand for some correction that a special governor's committee has studied the problem for several years. Under the capable direction of Clair Sawyer, the scientist in charge of the study, the committee has gathered an impressive mass of valuable data on this problem.

Several facts stand out from all this study in clear relief. Lake Mendota, above Madison, is clear, healthy, and highly productive from the standpoint of pan and game fishes. Although carp are present and relatively common, they have at no time become dominant in the lake, nor have they been the source of any considerable public alarm. There is, however, a sufficiently large and well established carp population in the lake which is capable of exploding into a "carp problem" at some time in the near future if domestic pollution wastes continue to be poured into Lake Mendota in increasing quantities.

Lake Monona, on the other hand, on the downstream side of the city, and for many years the direct recipient of the city's sewage waste, rapidly deteriorated as a fish-producing lake, although at one time it was considered much the better of the two lakes from the fisherman's point of view. Lakes Waubesa and Kegonsa, still farther downstream, have likewise altered in character.

For some years the state of Wisconsin has maintained rough fish removal crews on these lakes to remove the carp in an attempt to alleviate the problem, without any noticable effect. The annual harvest of the carp from the productive waters of these three lakes is actually higher than many men will admit is possible as the total standing crop. The exact figures will soon be released in a report prepared by other workers and cannot be given here.

One of the most significant developments is the observed fact that when the sewage effluent was moved downstream from Lake Monona to Lake Waubesa the carp harvest gradually began to decline in Lake Monona and the game and pan fish population began to recover.

Here, then, is an extreme case where the character and degree of domestic pollution can be measured directly in terms of changing character of the fish population. The complete reports on the Madison lakes when finally published should go far toward providing a yardstick to measure the effects of such pollution. In final analysis, as this author has long insisted, there is no "carp problem" as such, but simply a "pol-

lution problem,'' and when the latter is solved the balance in the fish pollution is quite likely to reestablish itself on a favorable basis.

The same so obviously holds true for the waters of the Illinois River that no comment is needed. Certainly every other factor connected with fish production and favoring the carp is better in the lower reaches of the White River in Arkansas than in the Illinois River, yet in Arkansas there is no carp problem. There are, however, flourishing fisheries for commerically valuable species as well as a considerable sports fishing development. The one thing lacking in Arkansas is sufficient pollution to spoil the water for the other fishes and leave the carp as the only species able to stand the extreme conditions. The fish population of Western Lake Erie is still another classic example of a change in fauna because of pollution.

The excellent early work of Forbes and Richardson offers a fine point of departure for comparative fish fauna studies which could easily be correlated with the degree of pollution in the various Illinois waters. It is a field of study which should be productive of many informative reports and which, if approached from the point of view I have indicated, would go far toward establishing exactly what is and what is not pollution damage.

The same approach should be made to the soil erosion problem. So far as the author is aware this has never been done, and this also in spite of the fact that fisheries, biologists, and systematic ichthyologists year after year have noted such items as ''formerly abundant, now rare'' in their reports about one species after another. Certainly many taxonomists are confident that the depletion of many species is more likely due to erosion and its resultant silting of streams than to any other factor or combination of factors.

The extinction of the hare-lipped sucker, *Lagochila lacera* appears to be directly correlated with the silting of its habitat streams by soil erosion. The near extinction of *Placopharynx carinatus* seems to be based on the same cause. Jordan and Gilbert (1886) reported both these species ''not rare'' in the White River near Eureka Springs, Arkansas. *Placopharynx* in this same report is termed ''abundant'' from the Ouachita and Saline Rivers near Arkadelphia and Benton, Arkansas. Jordan and Evermann (1896) reported *Placopharynx* ''abundant in the larger streams, especially in the French Broad and in the Ozark region.'' Of *Lagochila* they reported ''abundant only in the Ozark Mountains,'' but also listed several streams from which this species was known. No comment was made concerning its rarity in any waters.

Lagochila appears never to have been heard of again in the Ozarks. There was a lapse of some years before serious collecting was attempted in the Ozarks, and when collectors went into the area specifically after *Lagochila* and other rare Ozark fishes they did not return with a single specimen of the hare-lipped sucker. The writer has gone to considerable trouble to find specimens of *Lagochila* and *Placopharynx* in the Arkansas Ozarks but with no success. Certainly these streams have not been fished out, and save from

the damaging effects of sawmills have been noticably free of pollution. One outstanding change has occurred. The timber has been cut from the hillsides, and streams that once flowed evenly and clearly the year round have changed to up-and-down streams, nearly dried up part of the year, and swollen with mud-laden run-off torrents at other times. It seems rather obvious that these two fishes have joined the growing list of "used to be" species that once were common before man improved the countryside. Fifty years ago *Placopharynx* was so common in the Arkansas River near Fort Smith that farm boys frequently would fill a wagon bed with the fish in a short time of spearing and netting and haul them into the city to peddle out on the streets. Over-fishing might have contributed to the relatively sudden disappearance of *Placopharynx* but it seems that this sucker pretty well held its own until the white man went into Oklahoma and Kansas and plowed up the prairie to send it down to the Gulf in a yellow, boiling flood every time it rained.

In summation it is here suggested that some profitable studies could be made on the effects of pollution and soil erosion by a direct study of the changing character of the fish population, and that the fishes themselves serve as the best possible indices to the effects of these adverse conditions upon our fish fauna.

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A SURVEY OF THE UNIONIDAE OF THE UPPER REACHES OF THE MACKINAW RIVER

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This survey attempted to ascertain the genera and species of Unionidae currently present in the upper two-thirds of the Mackinaw River, a relatively short river of Central Illinois pursuing generally an east to west course. Its source is in the vicinity of Anchor, McLean County, and it empties into the Illinois River just south of Pekin, Tazewell County.

The survey was made during the second, third, and fourth weeks of October 1948, under conditions of low water which greatly facilitated collecting. The mussels were collected by hand and stations were examined from the headwaters to a point where the stream had become considerably larger.

Station 1 was established about five miles southeast of Anchor, and the area of search was about one quarter of a mile. The stream bed varied from light to medium gravel with occasional muddy areas; the stream being one to eight feet wide and two to fourteen inches deep, with a velocity of one-half mile per hour. No mussels were found due to seasonal variance of water depth which discouraged a consistent fish population.

A second examination (Station 2), was made three miles farther downstream. River conditions were similar to those at the first station except for increases in depth and width. Here, living thin-shelled mussels, of small size, were found in considerable abundance: *Alasmidonta calceolus* (48), *Anodontoides ferrussacianus* (15), *Micromya iris* (9), *Strophitus rugosus* (1). In the clear water, clam tracks were readily discernable, which facilitated the discovery of the mussels.

The third station was located one-half mile south of Anchor. No appreciable change in stream conditions from Station 2 was noted; however, the following additional genera and species were found: *Anodontoides ferrussacianus* (50), *Micromya iris* (25), *Strophitus rugosus* (17), and *Alasmidonta calceolus* (17). Clams appearing for the first time were *Anodonta grandis* (1), *Carunculina parva* (1), and *Lampsilis siliquoidea* (1). The last is a heavy-shelled mussel.

At the junction of the river and state route 165, immediately southwest of Colfax, the fourth station on the survey was established. In the intervening distance of approximately five miles from the station near Anchor, the river conditions had changed considerably. Primarily, there was an increase in width, averaging four to eighteen feet, while the stream bed became rocky in areas, in addition to being composed of light to medium gravel with occasional muddy regions. Live specimens of both the thin and heavy-shelled varieties were plentiful. In addition to previously lo-

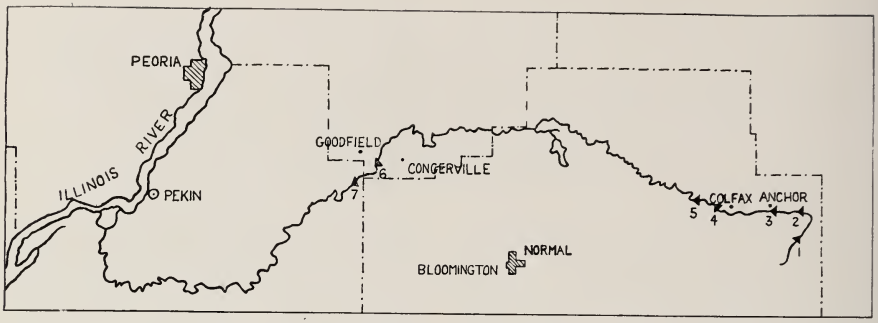

Fig. 1.—Mackinaw River and location of stations from which mussels were collected.

cated varieties, *Anodontoides ferrussacianus* (12), *Carunculina parva* (7), *Anodonta grandis* (5), *Micromya iris* (2), and *Strophitus rugosus* (2), excellent young and older living specimens of *Lasmigona complanata* (13), *Lasmigona compressa* (1) and *Leptodea fragilis* (1) were found.

Station 5 was established three miles farther downstream. River bottom conditions, except for slight increases in depth and width, were essentially similar to those of the previous station. Many of the foregoing living varieties were again found, *Anodonta grandis* (6), *Strophitus rugosus* (6), *Lasmigona complanata* (5), *Lampsilis siliquoidea* (4), *Anodontoides ferrussacianus* (3), *Micromya iris* (3), and *Lasmigona compressa* (1). However, two additional genera and species were revealed, i.e. *Amblema costata* (1) and *Fusconaia flava* (1). Prior to this station and Station 4, thin-shelled clams predominated, but at this point in the survey, now definitely showing larger stream characteristics, heavy-shelled mussels began to occur quite commonly. Van der Schalie (1936, 1938a, 1938b) mentions several of the above-listed forms as being common to middle-sized rivers.

Station 6 was located at Mackinaw Dells, two miles northwest of Congerville, Illinois, and approximately thirty-five miles from Colfax. The river bed was medium-coarse sand with considerable rocks. Possibly due to pollution of the river in this area, no living mussels were located; but considerable numbers of dead valves were found. In addition to the previously attained Unionidae, the dead shells included the succeeding genera and species: *Lampsilis ventricosa* (9), *Quadrula pustulosa* (8), *Elliptio dilatatus* (6), *Proptera alata* (5), *Quadrula quadrula* (4), *Pleurobema coccineum* (2), *Lasmigona costata* (2), *Quadrula metanevra* (1), *Alasmidonta marginata* (1), *Actinonaias carinata* (1) and *Micromya lienosa* (1). Since some of these species were not evinced by living representatives farther upstream, we have evidence that they had at sometime been established, but had been destroyed by changed river conditions. Also,

there is the possibility that ice, during spring thaws, transported the valves downstream.

Station 7 was instituted two miles southwest of Goodfield, and about four miles downstream from Mackinaw Dells. Aside from being considerably more rocky, river bottom conditions approximated those of Station 6. Living clams, previously found only as dead valves at Station 6, were located: *Lasmigona complanata* (5), *Quadrula pustulosa* (2), *Alasmidonta marginata* (1), *Lampsilis siliquoidea* (1) and *Strophitus rugosus* (1).

As a result of the survey, fourteen genera and twenty-one species of Unionidae were collected and observed.

In its course, the river does not flow through urban or industrial areas; therefore, the water is relatively free from pollution. It has been observed that freshwater mussels are among the first residents of an aquatic habitat to disappear when pollution occurs. Baker and Smith observed this previously in their research on the upper Vermilion River (Baker and Smith, 1919).

Invaluable assistance was received from Dr. Max R. Matteson and Dr. Harley J. Van Cleave of the University of Illinois.

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NOTES ON THE BIOLOGY OF A COMMON GASTROTRICH OF THE CHICAGO AREA *LEPIDODERMA SQUAMATUM* (DU JARDIN)

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Introduction

Although the Gastrotricha have been elevated to the category of a phylum since 1936 by the Committee on Nomenclature of the Zoological section of the American Association for the Advancement of Science, no other group of fresh water animals has seemingly been as greatly neglected by research workers in this country. European observers since Du Jardin (1841) have contributed most of our information concerning this group, including several comprehensive monographic treatments by such workers as Zelinka (1889), Grunspan (1910), and Remane (1936). However, with the exception of the studies of Stokes on the Gastrotrichs of New Jersey in 1887 and 1888, and those of Brunson (1947), very limited observations have been made in the United States. The author has been making collections of this group for several years for taxonomic and speciation studies to be published at a later date. This paper is a brief report on various factors of the biology and life history observations made on a single species.

The species of most general distributions in the Chicago area keys out as *Lepidoderma squamatum* in Ward's taxonomic key included in "Fresh Water Biology" by Ward and Whipple (1918), and it shows little or no variation from written descriptions of this species derived from Du Jardin's original type species. Since holotype European specimens are not available, the assumption is that this study is concerned with a geographical variant of the original European species.

Ecology and Distribution

Collections of this species were made over the summer months of the years 1946 and 1947 in the vicinity of the Chicago area from both running stream and temporary pond habitats. This species has been found repeatedly in collections from the Des Plaines River. Although no precise quantitative measurements were made, it became apparent from the habitat sources that this species requires a moderate amount of oxygen concentration in a fresh water habitat that contains very minimal amounts of organic contamination. When this organism was transferred to the laboratory and raised in an artificial medium, it required the control of pH by addition of a buffer for successful culturing.

Pure Culture Technique

Successful pure line culture technique was made possible by the isolation of single individuals through the employment of a micropipette and their introduction into glass

finger bowls containing spring water which had been conditioned by being allowed to stand for ten days and containing several rice grains which were then allowed to ferment within the water. Several of these pure line cultures were maintained for more than a year and required only the addition of a few grains of rice every three to four weeks and the replacement of water lost through evaporation. Various different types of culture media were tested, including infusions of oats, corn, peas, and hay as well as the method of cultivation by using malted milk powder described by Packard (1937). None of these were as successful as rice in maintaining cultures, and complete negative results were obtained with Packard's malted milk medium. Life history observations were made on isolated individuals grown in hanging drop preparations and in shallow depression slides.

Life History Stages

The adult animal has the body externally divided into superficial regions of head, neck, and trunk which appears to be generally characteristic of all species of fresh water Gastrotricha. Measurements made on mature living specimens show a slight variation in length between 120 to 148 mu. The width of the head varies between 20 to 25 mu, that of the neck is approximately 20 mu, and the width of the abdominal region varies between 25 to 30 mu. The body is distinctly scaled and the ventral surface bears several longitudinal rows of cilia. The head of this species is rounded anteriorly and bilobed on each lateral surface. Groups of cilia in tuft formations are found on the lateral surfaces of the head. At the posterior end the trunk forks into a pair of caudal appendages which vary in length between 23 to 26 mu. Internally, a rather heavily walled pharynx can be seen which terminates anteriorly in a mouth-like opening and posteriorly leads to the stomach-intestine. The mature form can be readily distinguished from the immature larval forms by the larger size and by the usual presence of a single large developing ovum located in the posterior third of the body.

Several hundred specimens were studied for evidence of a possible differentiation as to sex or the possibility of the existence of hermaphroditism. Histological sections were made in the search for male gonads. In all instances these observations were negative so that this organism must still be considered as reproducing only by parthenogenesis. All experimental attempts to produce a male type of organism by simulating environmental temperature variations or by the employment of sublethal temperature shocks on both egg and adult failed also in this respect.

Population clones developed from single isolated individuals which varied in size from minimal to maximal measurements showed the same variations in these characteristics as is found in any mixed population. It is thus concluded that such variations are environmentally produced and are related to some factor such as nutritional differences among individuals. Remane (1927) considers the marine Gastrotrichs as being the primitive members of this group, and the degenerate nature of *L.*

squamatum became somewhat evident with the difficulty encountered by this observer to experimentally produce genetic variations in isolated populations.

The egg of *L. squamatum* is oval in shape and has a mean length of 45 mu and a mean width of 25 mu. It appears to be covered with a chitinous-like material and bears numerous spine-like processes over the surface which appear after oviposition has occurred. The eggs are deposited on the bottom of the culture dish, usually in the vicinity of the fermenting rice media. Within the adult, the egg develops into a large cell occupying the entire posterior third of the animal. It appears as a prominent nucleus surrounded by a considerable amount of cytoplasmic material. In experimentally subjecting pure line cultures to variable constant low tempertures and to temperature shock treatment, the egg retained its viability even when maintained at approximately 4°C. Since the adults were killed off by prolonged low temperatures, it seems likely that the overwintering stage for this species in this area is in the egg.

The egg also appears to have a great deal of resistance to desiccation over extended periods of time, although this does not appear to be a necessary element in the life cycle. Three glass finger bowl cultures were allowed to dry out by evaporation at room temperatures and after a period of three weeks, the liquid was replaced by the addition of conditioned spring water. In two of the three cultures living specimens of this species were found once again after two weeks time.

Metchnikoff in 1865 described two kinds of eggs, "summer" and "winter," for the species *Chaetonotus larus*, and Remane (1926) describes a similar condition of two kinds of eggs for the species *C. persetosus*. He notes, however, that these are not to be considered as summer and winter eggs since the so-called "winter eggs" are produced throughout the year. This observer has failed to find other than a single type of egg for the species *Lepidoderma squamatum*, despite experimental attempts to produce variant types by subjecting the organism to temperatures ranging from 4°C. to 28°C. It is thus felt that experimental observations seem to preclude the question of summer and winter eggs for this species.

Summary

Collections from fresh-water ponds and streams over several seasons have indicated that the species *L. squamatum* is the most generally distributed species of Gastrotricha in the Chicago area. This organism has been successfully maintained as pure cultures in artificial infusion media, and observations were made on its life history stages. Only a single type of egg could be observed to be produced under controlled and varying experimental temperature fluctuations and this egg proved to be viable under rather prolonged extreme low temperature conditions and periods of desiccation. Thus it is suggested that the egg serves as the carrying-over stage when the organism encounters adverse environmental conditions and this may be the explanation for rather wide distribution of this species in both Eur-

ope and the United States. The egg of this species appears to be of a single type, even when tested under varying experimental conditions, and this would seem to dispel the possibility of seasonal types of eggs which have been described in the literature for other species. Adults appear under all circumstances to be unisexual and undergo true parthenogenetic reproduction. Size variation could not be shown to be a genetic constant in population clones derived from single individuals varying from minimal to maximal measurements.

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GENETIC VARIATION IN POPULATIONS OF *DROSOPHILA MELANOGASTER* IN THE CHICAGO AREA

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In the summer of 1947 hundreds of *D. melanogaster* were trapped at several localities in the metropolitan area of Chicago with the purpose of determining the amount of visible mutations and second chromosome lethals in each population. With this information one would be able to analyze the genetic structure, the size of the breeding population, and determine whether a continuous breeding population was present in this particular area.

The flies were caught by baiting half-pint bottles with bananas, and placing the bottles in clumps of bushes, usually in parks or empty lots. Collections were made at three locations: one on the south side, one on the southwest side, and the other one on the north side. Each station was at least ten miles from the other two. Visible mutants were obtained by inbreeding seven F_1 pair-matings. The advantages of this method were ably stated by Spencer (1947). The lethals on the second chromosome were determined by using L/Cy as markers and inbreeding in such a manner as used by Ives (1945) in that the appearance of all Curly winged flies in the third generation would be indicative that a recessive lethal was present on one of the 2nd chromosomes of the original male parent.

The inbreeding for the 2nd chromosome lethals and the F_2 pair matings for visible recessives were done as soon as possible after the arrival of the flies in the laboratory. If they were not mated then they were transferred to a large culture bottle, and 200-400 flies were transferred monthly.

The visible mutation which was the most predominate in the Chicago area in the summer of 1947 was trident (*tri.*), a trident or streak of dark pigmentation on the thorax and scutellum. This mutant gene was found in all but one of the collections made in 1947 (see Table 2). In one collection 81.1 percent of the pair-mating which was inbred produced flies containing *tri.* The population might have gone through a bottle neck in that it was reduced to a few individuals in number. The few remaining flies contained a large number of *tri* genes. A collection at the same location two months later yielded 47.3 percent *tri.* Another mutant gene which was abundant in Drosophila populations was angle wing (a second chromosome mutant in which wings are held out at a 45° angle from the long axis of the body); this mutant gene was present in all but two of the collections.

The highly variable genetic nature of Drosophila populations in a metropolitan area is illustrated by collections No. 5 and No. 6, both from the same locality and 13 days apart.

TABLE I.—PERCENTAGE OF SECOND CHROMOSOMES TESTED THAT CONTAINED LETHALS

Stock number	Place collected	Date	Percentage of 2nd chromosomes that contain lethals	Total tested
1	4000 S. 1000 E.	8/15/47	31.1	93
2	4000 S. 1000 E.	8/22/47	4.16	106
3	4000 S. 1000 E.	8/22/47	15.2	118
5	8500 S. 2400 W.	8/29/47	34.2	120
6	8500 S. 2400 W.	9/11/47	57.1	99
10	5900 N. 1500 W.	9/18/47	5.1	83
11	4000 S. 1000 E.	10/26/47	27.4	102

TABLING II.—VISIBLE MUTATIONS OBTAINED BY INBREEDING F_1 PAIR-MATING
(In percent)

Mutation	No. 1	No. 2	No. 3	No. 5	No. 6	No. 10	No. 11
tri	41.2	81.1	....	29.3	10.6	8.6	47.3
b	12.5	....	....	....	77.7	....	5.3
w	8.6	....	....	....	....	....	....
ss	12.1	....	5.2	....	21.3	....	....
st	4.5	....	....	....	....	....	....
angle wing	8.1	7.5	5.5	....	23.2	49.2	....
net	....	....	....	....	11.4	....	....
extra vein	....	....	....	....	....	....	5.2
cmp	....	....	....	....	....	8.3	10.5
w^e	....	....	2.2	....	....	....	....
ma	....	....	....	....	22.1	....	....
se	....	....	....	....	11.2	....	....

In No. 5 only one mutant *tri* was rerecovered, but in No. 6 seven mutations were found. In No. 5, 34.2 percent of the 2nd chromosomes tested contained lethals and No. 6 contained 57.1 percent 2nd chromosome lethals.

The percentage of 2nd chromosomes that contained lethals varied from the time of one collection to another. One collection, No. 10 (north, side) contained 5.1 percent of lethals, and No. 6 (south side) possessed 57.1 percent second chromosome lethals (see table 1).

How can one account for the tremendous variation in the above collection in regard to visible mutants and recessive second chromosome lethals? One conclusion reached is that *Drosophila melanogaster* breeds in isolated small populations in large metropolitan areas. The small isolated groups can vary greatly from one another in that, at the time of reduction of population in the fall, different visible mutations and lethals are retained by the small groups of surviving flies. In the spring, the small groups expand rapidly in numbers and move into unoccupied areas. There must be a rapid movement or mixing of flies during the summer to account for

the daily variation in population structure at one point. Ives (1945) reported that his work with 2nd chromosome lethals in *D. melanogaster* populations in a rural area near Amherst, Mass., indicated that the flies breed in continuous populations. However, Ives (1948) found that there was a seasonal shift in lethals from summer of 1946 to summer of 1947. There is a strong possibility that *D. melanogaster* breeds in small discontinuous populations in the cities and in continuous populations in rural areas.

The presence of the *tri* in all but one population indicates that the small populations at times (probably late in the summer) expand to such proportions that there is an overflow of flies from one population to another. The populations do not remain genetically isolated from one another. The flies heterozygous for *tri* may have a selective advantage over the non-*tri* flies, and hence become fixed in the population. Reed and Reed (1948) found that a lethal inversion flourishes in the heterozygous state in the laboratory. Again this can account for the relatively high number of lethal mutations on the second chromosomes.

The study of Chicago *D. melanogaster* populations is continuing. The populations of several summers are being compared. The genetic variation of a population from one year to another year at the same location is being obtained. The weather and its influence is being correlated to the genetic fluctuation.

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INCIDENCE OF TRYPANOSOMA INFECTION IN SMALL MAMMALS OF CHAMPAIGN COUNTY, ILLINOIS

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One might very well ask the value of a study such as is reported here. Is it of any practical value beyond the mere accumulation of information?

It is well known that the brown rat is one of man's worst pests. Every year this rodent cheats mankind out of millions of dollars worth of food. It carries lice and fleas which spread plague, typhus, and many other diseases. Any information which may help to cut down the population of rats is of great value.

A rat which is infected with a blood parasite such as *Trypanosoma lewisi* is a sick animal. Hence, it is less able to cause harm to man. Even if the parasite does not directly cause the death of the host, it must be considered pathogenic. It is robbing the host of needed energy.

Wenyon (1926) reports a method for increasing the virulence of trypanosomes by passing them rapidly through a series of rats. If, then, it were possible to infect large numbers of rats with these organisms we might have a biological method for control of rodents.

The work reported here was done in the spring and fall of 1948 between the first of April and early November. Altogether fifty-nine rodents and seven shrews were examined for blood parasites.

The animals were trapped in Sherman live traps fitted with boxes of waste to protect them from the cold. Sunflower seed and corn were used as bait. Trapping was done in an area of fifteen miles radius from Champaign, Illinois. Traps were set in ten different places throughout this area. Part of the work was done in conjunction with a population and distribution study being made by Ralph M. Wetzel in the Trelease woods and grassland, a property of the University of Illinois. The animals obtained there were marked, blood for smears obtained by clipping the tip of the tail, and the animals released. In trapping other places the animals were brought back to the laboratory for study.

The species trapped and the number of each examined are as follows:

Species	*Number examined*
Prairie vole, *Microtus ochrogaster* (Wagner)	21
Woodland deer mouse, *Peromyscus leucopus* (Fischer)	11
Prairie deer mouse, Peromyscus maniculatus (Hoy and Kennicott)	15
Common house mouse, *Mus musculus* Linnaeus	7
Common brown rat, *Ratus norvegicus* (Erxleben)	5
Short-tailed shrew, *Blarine brevicauda* (Say)	7

Identification of the above was by Mr. Wetzel.

Only two species, the brown rat and the microtus, were infected by trypanosomes. Of the 21 microtus examined, fourteen (66.6 percent) were infected. Only five rats were examined, but of these two were infected. The trypanosome found in

the rats conforms with the description of *Trypanosoma lewisi* (Kent) as given by Kudo in the 1947 edition of his Protozoology. It is therefore presumed to be *T. lewisi.*

Laveran and Pettit (1909) described a species of trypanosome found in the European field vole, *Microtus arvalis* Pallas. They proposed to call this organism *Trypanosoma microti.* Since that time several writers have recorded the occurrence of the organism in other species of microtus. Coatney (1935) found it in *Microtus pennsylvanicus.* Wood and Wood (1937) found the organism in *Microtus californicus.* Laveran and Pettit (1909) and Wenyon (1926) each give one drawing of the trypanosome. No record has been found in the literature for the occurrence of the flagellate in *Microtus ochrogaster.*

This trypanosome agrees very closely with the description of *T. microti* as given by Laveran and Pettit (1909) and by Coatney (1935) with one exception. The blepharoplast of the trypanosome found by the writer is much enlarged. In this respect there is a certain resemblance to *T. cruzi,* but when compared directly with *T. cruzi,* it is obvious that they are not the same. Two attempts were made to inoculate the organism into white laboratory rats, but without success. It is therefore concluded that the organism described here is *T. microti.*

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PARASITES OF THE RANIDAE (*AMPHIBIA*). XIV*

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No. 72. *Rana pipiens,* the common leopard frog of North America and standard equipment in almost every biological laboratory, has a range from Canada down through the United States east of the Rocky Mountains into Mexico. In addition to furnishing excellent material for the study of anatomy, histology, embryology, and physiology, this animal has proved a treasure-house as a source of parasites of a wide variety of types. During thirty years of use of live frogs (sent in from 18 states, 1 region in Mexico, and 2 provinces of Canada), more than fifty species of parasites have been found, about thirty of which occur fairly commonly. Interest of students has led to a search of available literature and the list has been expanded considerably.

Rana pipiens apparently serves as a host to a wide variety of parasitic protozoa, and although possibly only an accidental host to some, is a normal host to many. In addition, a few free-living forms seem to find satisfactory living conditions on the surface of the frog's skin. Tadpoles, possibly because of their feeding habits, seem to be more frequently hosts to such non-parasitic species than do the adults. Only one species of internal parasite—*Opalina larvarum*—seems to be restricted to tadpole hosts, and has been reported quite frequently from tadpoles captured in northern waters. Most of the parasites of the adults are intestinal forms, although a few are found embedded in the muscles or free in the blood stream. More than thirty species have been reported from *Rana pipiens,* of which eleven are fairly abundant. Twenty genera of protozoa are represented.

* Contribution from the Biological Laboratories of Knox College, No. 129.

PROTOZOA

Canada:

Haemogregarina sp? of Scott, 1928. Blood.
Leptomonas ctenocephali (experimental). Intestine.
Trichomonas augusta. Intestine.
Trichomonas batrachorum. Intestine.

Mexico:

Cepedea mexicana. Intestine.

U. S. A.:

Chilomastix sp? of Wenrich, 1947. Intestine.
Endolimax ranarum. Intestine.
Euglena sp? of Hegner, 1923 (on tadpoles). Skin.
Haemogregarina sp? of Kudo, 1922. Blood.
Haptophrya michiganensis. Intestine.
Hexamita batrachorum. Intestine.
Hexamita intestinalis. Intestine.
Hexamita ovata. Intestine.
Hexamita (*Uraphagus*) sp? of Wenrich, 1935. Intestine.
Karotomorpha bufonis. Intestine.
Karotomorpha swezyi. Intestine.
Leishmania donovani (experimental). Intracellular.
Leptotheca ohlmacheri. Body cavity cysts.
Mastigamoeba hylae. Intestine.
Myxidium serotinum. Bladder.
Nyctotherus sp? of Zebrowski, 1923. Intestine.
Opalina larvarum (in tadpoles). Intestine.
Opalina obtrigonoidea. Intestine.
Opalina obtrigonoidea austricola. Intestine.
Opalina triangularis. Intestine.
(? = *O. obtrigonoidea*)
Phacus sp? of Hegner, 1922 (on tadpoles). Skin.
(? = *P. pleuronectes*)
Retortamonas dobelli. Intestine.

Trepomonas sp? of Wenrich, 1947. Intestine.
Trichomitus parvus. Intestine.
Trichomonas augusta. Intestine.
Trichomonas batrachorum. Intestine.
Trimitus parvus. Intestine.
Trypanosoma rotatorium. Blood.
Trypanosoma sp? of Drbohlav, 1929. Blood.
Trypanosoma sp? of Nigrelli, 1945. Blood.

Among the Nematodes, about twenty species have been recorded, of which ten are fairly common. Five species of larval forms have been reported, of which one, *Icosiella* sp., is quite common as an encysted form in the body cavity and in the superficial body muscles. The species *Pharyngodon batrachiensis* becomes adult in the tadpole. Fourteen genera are reported.

NEMATODA

Canada:

Cosmocercoides dukae. Rectum.

Mexico:

Foleyellides striatus. Peritoneum (larvae in blood).

U.S.A.:

**Agamascaris odontocephala*. Liver and stomach cysts.
Camallanus microcephalus. Intestine.
Camallanus pipientis. Intestine.
Cosmocercoides dukae. Intestine.
**Eustrongylides ignotus*. Peritoneal cysts.
*"*Filaria*" sp? of Leidy, 1852. Intestinal cysts.
Foleyella americana. Mesenteric cysts (larvae in blood).
**Icosiella quadrituberculata*. Muscle cysts.
Oswaldocruzia pipiens. Intestine.
Oswaldocruzia subauricularis. Intestine.
Oswaldocruzia waltoni. Intestine.
Oxysomatium americana. Rectum.
Oxysomatium georgianum. Rectum.
Oxysomatium longicaudata. Rectum.
Pharyngodon armatus (female only). Intestine.
Pharyngodon batrachiensis (female only), (in tadpoles). Intestine.
**Physaloptera* sp? larva of Morgan, 1941. Stomach cysts.
Rhabdias ranae. Lungs.

The Trematodes are the most abundant and best known group of parasitic worms found in *Rana pipiens*. Sixteen species from eight genera are reported from Canada. Three are larval forms; the adult of only one of these is known. Although the frog may serve as an intermediate host in the life cycle of many flukes, few instances of such intermediate stages have been reported from Canadian examples of *pipiens*. Only seven species from five different genera have been reported from Mexican hosts; all of these apparently finding the frog as their definitive host. Among the flukes reported from the United States, thirty-five species from sixteen genera are recorded from *R. pipiens*. Sixteen of these species are fairly common. Possibly because of a greater number of observers, more of the trematode parasites of the tadpole are reported; at least eleven species have been recorded. Of these at least two become sexually mature in the adult frog. The others (where their life cycle is known) reach maturity in reptiles, birds, or mammals. For a number of parasites life cycles are not as yet completely known so that the ultimate adult and its host cannot be recorded.

TREMATODA

Canada:

Cephalogonimus retusus. Intestine.
**Cercaria vesiculosa*. Encyst in throat muscles.
**Distoma nitidum*. Stomach cysts.
Glypthelmins quieta. Intestine.
Gorgodera amplicava. Bladder.
Gorgodera cygnoides. Bladder.
Gorgoderina attenuata. Bladder.
Gorgoderina simplex. Bladder.
Gorgoderina translucida. Bladder.
Haematoloechus breviplexus. Lungs.
Haematoloechus medioplexus. Lungs.
Haematoloechus similiplexus. Lungs.
Haematoloechus variegatus. Lungs.
**Lechriorchis primus* (in tadpoles). Intestine.
Manodistomum occultum. Intestine and muscle cysts.
Megalodiscus temperatus. Intestine.

* Denotes larval forms.

Mexico:
Cephalogonimus americanus. Intestine.
Glypthelmins californiensis. Intestine.
Gorgoderina attenuata. Bladder.
Haematoloechus macrorchis. Lungs.
Haematoloechus medioplexus. Lungs.
Haematoloechus varioplexus. Lungs.
Halipegus lermensis (?=*H. occidualis*). Eustachian tubes.

U.S.A.:
**Alaria intermedia* (also in tadpoles). Muscle and kidney tissue.
**Alaria marcianae* n. comb. (=*Cercaria marcianae* LaRue, 1917) (in tadpoles). Muscle.
**Alaria micradena* n. comb. (=*Cercaria micradena* Cort and Brackett, 1938) (in tadpoles). Nerve cord.
**Alaria mustelae* (also in tadpoles). Muscle tissue.
Alassostoma parvum. Rectum.
**Apharyngostrigea pipientis* (in tadpoles). Intestine.
Cephalogonimus retusus. Intestine.
**Cercaria elodes* (enters tadpole). Notochord.
**Clinostomum complanatum.* Muscles.
**Diplostomulum vegrandis* (in tadpoles). Muscles.
**Diplostomum flexicaudum* (in tadpoles). Eye and muscle tissue.
**Distoma nitidum.* Stomach cysts.
*Distome metacercariae of Stabler and Pennypacker, 1939. Liver cysts.
**Euryhelmis monorchis* (also in tadpoles). Subcutaneous tissue.
**Eruyhelmis squamula* (also in tadpoles) (probably *E. monorchis*. *E. squamula* is the European form). Subcutaneous tissue.
Glypthelmins quieta. Intestine.
Glypthelmins subtropica. Intestine.
Gorgodera amplicava. Bladder.
Gorgodera cygnoides. Bladder.
Gorgodera minima. Bladder.
Gorgoderina attenuata. Bladder.
Haematoloechus coloradensis. Lungs.
Haematoloechus complexus. Lungs.
Haematoloechus longiplexus. Lungs.
Haematoloechus medioplexus. Lungs.
Haematoloechus similiplexus. Lungs.
Haematoloechus variegatus. Lungs.
Halipegus eccentricus (also in tadpoles). Eustachian tubes.
Halipegus occidualis. Mouth and ears.
**Lechriorchis primus* (in tadpoles). Mouth and intestine.
**Lechriorchis tygarti* (in tadpoles). Mouth and intestine.
Loxogenes arcanum. Visceral cysts and intestine.
Megalodiscus temperatus (metacercariae and adults in tadpoles and adult frogs). Metacercariae in skin, adults in intestine.
Monostoma ornatum. Body cavity.
**Zeugorchis erinus* (in tadpoles). Intestine

* Denotes larval forms.

Alaria marcianae and *Alaria microdena* are presented as new combinations inasmuch as the metacercariae of these forms from the frog have been experimentally raised (particularly *A. microdena*) in pigeons and seem to belong to the genus *Alaria*. The original reports of these experiments pointed out the proper position of the metacercariae but did not make the combinations indicated.

Members of the Cestoda are not common in *Rana pipiens* but a few specimens of *Cylindrotaenia* are found each year in the frogs collected in the field. *Cylindrotaenia* (2 species) and *Nematotaenia dispar* become adult in the frog, although the record for *N. dispar* (a European form) is possibly a misidentification of a *Cylindrotaenia* species. Larval forms of *Ophiotaenia perspicua* have been reported from tadpoles, and one record of this form as an adult in adult frogs has been listed. Unidentified larval tapeworms are frequently present in adult frogs, but identification is difficult and seldom attempted.

CESTODA

Canada:
?*Nematotaenia dispar.* Intestine.
U. S. A.:
Cylindrotaenia americana. Intestine.
Cylindrotaenia quardijugosa. Intestine.
**Ophiotaenia perspicua* (also in tadpoles). Liver of tadpoles.
Proteocephalidae of Fortner, 1923. In cysts.

Two leeches—*Haementeria montifera* and *Macrobdella decora*—have been taken from the surface of adult frogs collected at various stations in the United States.

One larval mite—*Hannemania penetrans*—has been recorded several times from specimens of *R. pipiens* caught in the southern United States.

At least six species of mosquitoes are known to feed on the blood of the adult frog, and several have been shown to be the vectors of microfilariae of at least three species of *Foleyella,* although *F. americana* is the only microfilariid definitely recognized from *R. pipiens.*

DIPTERA

Aedes aegypti.
Aedes atropalpus.
Culex apicalis.
Culex fatigans.
Culex pipiens.
Culex quinquefasciatus.

Probably the surfaces of both tadpoles and adults carry a rich bacterial flora, but only three species of internal parasites are known . One, *Proteus hydrophilus,* is the case of "red-leg disease" which so frequently plagues the aquarium stock of our laboratories. Another is an intestinal form indistinguishable from *Eschreichia coli.* The third is an acid-fast form—*Mycobacterium ranae*—although it is questionable whether tuberculosis is a "white plague" among the Amphibia. A number of forms isolated from fish and reptiles have been grown successfully in Amphibia. A more thorough study would undoubtedly increase our knowledge of the parasitic flora of Amphibia greatly.

BACTERIA

U. S. A.:
Escherichia coli. Intestine.
Mycobacterium marinum (experimental). Tissues.
Mycobacterium piscium (exp.). Tissues.
Mycobacterium ranae. Tissues.
Mycobacterium thamnopheos (exp. in adults and tadpoles). Tissues.
Proteus hydrophilus. Muscle tissue.
Serratia anolium (exp.). Intestine.

The fish mold *Saprolegnia parasitica* (Oömycetes) frequently attacks frogs kept in the laboratory aquarium.

At least two species of protozoans, four of nematodes, five of trematodes, and possibly one of tapeworms can be expected as parasites of almost every batch of *Rana pipiens* used in the laboratory, particularly if they were collected from the field and not raised commercially. In the latter case parasite collecting is usually poor. It adds interest, and possibly information, if students are encouraged to look for evidences of parasitism as well as to perform the usual laboratory exercises. Preserved as well as live material can be used, but one seldom finds other than nematodes, trematodes, and tapeworms in preserved frogs.

COLLEGIATE SECTION

CERTAIN FACTORS WHICH INFLUENCE ACTIVATION OF THE HEXACANTH EMBRYO OF THE FOWL TAPEWORM *RAILLIETINA CESTICILLUS*[1]

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While carrying out life history studies on the fowl tapeworm, *Raillietina cesticillus,* great variability was noted in the number of active six-hooked embryos found in different gravid proglottids collected from the feces of infected fowls. Proglottids, which are shed from the terminal portion of adult tapeworms, contain from 150 to 300 of these onchospheres or hexacanth embryos. In some preparations, made by teasing apart proglottids, all embryos remained quiescent, but in other preparations most of the embryos showed the remarkable breast-stroke-like activity which is typical of embryos in this stage of tapeworm life history.

Although the movements of the hexacanth embryos have been induced frequently in other species, (*Taenia taeniaeformis* by Bullock, Dunning, and Curtis 1934, *Taenia saginata* by Penfold, Penfold and Phillips 1937, *Dipylidium canium* by Venard 1938, and *Bertiella studeri* by Stunkard 1940) spontaneous hatching does not normally occur unless these larvae are first acted upon by enzymes or pressure. In *Raillietina cesticillus* the violent swinging action of the six hooks may result in rupture of both the embryophore and the outer uterine shell, thus freeing the embryo from surrounding membranes. The freed embryo normally works its way through the gut wall of a suitable species of beetle (Reid, Ackert, and Case, 1938). Within two to three weeks the onchosphere metamorphoses into a cysticercoid. If the beetle containing fully developed cysticercoids is eaten by a chicken, the freed larvae attach to the gut wall and grow to adult tapeworms.

A study of the factors inducing motility of the embryos was carried out for two reasons. First, an understanding of factors inducing motility would contribute to the knowledge of the life history of this organism and might help to explain the irregular infectivity of beetles under laboratory conditions. During attempts to produce cysticercoids for studies of the pathology or for treatment of this species, a low percentage of infestation has sometimes been encountered. A second reason for this study was to further enhance the use of these embryos for teaching purposes. Due to their large size and the transparent covering membranes, they make excellent demonstrations of this larval stage. However, inability to induce

[1] Portions of this study were carried out at the Marine Biological Laboratory, Woods Hole, Massachusetts, aided by funds made available through an American Association for the Advancement of Science grant awarded by the Illinois State Academy of Science.

movement of the larvae has at times made them less effective.

A systematic study of the effects of (1) osmotic pressure changes, (2) pH concentration, and (3) temperature changes is reported upon in the present study.

Materials and Methods

Fowls were infected and proglottids were collected, according to methods described by Reid (1942). The freshly passed gravid proglottids were stored in fluids or kept moist on filter paper in covered Stender dishes before the count was made. To count the active or inactive onchospheres the proglottid was teased apart, placed in fluid on a glass slide, and covered with a cover glass. The slide was then sealed with Vaseline to prevent evaporation. The first 100 embryos were counted with the aid of a mechanical stage and classified according to the three categories: (1) living and motile; (2) living and non-motile; and (3) dead. If an embryo showed either active movements which might result in hatching or only slow lazy movements, it was classified as motile. Dead embryos could be distinguished by clouding of the normal hyaline protoplasm and disorientation of the hooks. Since considerable variability was found in the amount of motility, in later studies each proglottid was cut in half with one half serving as a control while the other half received the experimental treatment.

Effect of Osmotic Concentration Upon the Embryo

Numerous comparisons were made between the motility of onchospheres in one percent saline solution and those maintained in distilled water or two percent saline solution. No marked increase in motility was induced by any of these solutions. However, numerous embryos died after 30 minutes of exposure to distilled water. In a representative case, 90 percent of the embryos were living but non-motile after five minutes exposure and ten percent were dead. After 30 minutes, 47 percent of these same embryos were living but non-motile and 53 percent were dead. Two percent saline also had a deleterious effect upon the embryos, but it was not as rapid. In a typical trial, eight percent of the embryos were dead after five minutes, nine percent after 30 minutes, and 62 percent were dead after one hour. Embryos maintained in one percent sodium chloride were affected little, if at all, by the treatment. In a count, two percent of the onchospheres were dead after five minutes exposure and three percent after 30 minutes. This study showed that of the solutions tested, one percent saline is the optimum osmotic concentration in which to store the embryos, but that osmotic changes do not induce motility.

Effects of pH upon the Embryo

Since embryos are subjected to pH changes in the gut of the host, the sensitivity of embryos to three different solutions was tested. Using a one percent sodium chloride solution buffered to a pH of 3.6 by means of a 0.2M acetate buffer, no motility was induced in the embryos, but 64 percent were dead after five minutes exposure. All were dead at the end of seventeen minutes. One percent

saline solution buffered to a pH of 8.0 or to a pH of 6.0 by means of phosphate buffer induced no motility, but exposure for 30 minutes did not kill the embryos. It is concluded that a change in pH is not the factor which results in embryo activation.

Effects of Temperature upon the Onchosphere

Preliminary tests indicated that an increase from room temperature (21±3°C) to 37°C did not induce motility, but possibly increased the mortality rate on embryos exposed for two hours. However, a decrease from room temperature to 6-7°C for a few hours not only induced marked increase in motility, but fewer embryos died. A more thorough study of the effects of lowered temperature carried out by one of us (Nice, 1949) definitely established the effects of exposure to cold in inducing motility. By counting 100 embryos from each of ten half-proglottids which had been stored at 1°C for eighteen hours, an average of 78.7 (range 56-91) embryos were found active in each half-proglottid. In the other half-proglottids which were used as controls and stored at 21±3°C for eighteen hours, only 0.1 percent of the embryos were motile, while 96 percent were living but non-motile. None of the embryos stored in the cold were dead, but 3.9 percent of those kept at room temperature died.

Discussion

The cold-induced activity of these onchospheres may have adaptive significance in the life history of the parasite. Successful infection of the secondary host depends upon penetration of the gut wall of the beetle through activity of the embryo. Onchospheres in this species seldom live more than a day unless the temperature is cool. It has been shown by Wetzel (1934) and confirmed by Reid, Ackert, and Case (1938) that the proglottids of *Raillietina cesticillus* are shed in larger numbers late in the afternoon. Many of the beetle hosts are nocturnal in their feeding habits so that proglottids shed late in the day are eaten during the following night when a natural temperature drop occurs. For natural infections the nocturnal temperature could not drop as low as the 1 C° used in the experimental study, since the beetles themselves would be inactive at that temperature. However, the greatest numbers of onchospheres are consumed during that period when the temperature is lowest. Lack of temperature control after collecting proglottids for laboratory infections may account for some of the variability in infestation which has been encountered by various workers.

Summary

1. Decrease from room temperature (21±3 C°) to 1 C° induced activity in 78.7 percent of 1,000 embryos as compared to 0.1 percent motility found in 1,000 controls maintained at room temperature.

2. No other factors studied induced motility. A pH concentration of 3.6, distilled water, 2 percent sodium chloride solutions, and maintaining the embryos at room temperature or above increased the mortality rate of embryos, but pH ranges of 6.0 and 8.0 and one percent saline did not hasten death of the embryos.

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MEMORIALS

CHARLES TOBIAS KNIPP

1869-1948

Charles Tobias Knipp was born on August 13, 1869 in Napoleon, Ohio. He attended Indiana University where he was graduated in 1894 and took his master's degree in 1896. He married Frances Winona Krause on June 25, 1896. He then served for two years as instructor in physics at Indiana University. In 1898-1900 he held the President White fellowship at Cornell University and there received his Ph.D. in physics in 1900. He then returned to Indiana University where he served for three years as Assistant Professor of Physics. In 1903 he joined the department of physics at the University of Illinois in which he served continuously until his retirement in 1937, with the successive ranks of Assistant Professor, Associate Professor, and Professor of Experimental Electricity. During the recent war he served as Visiting Professor of Physics at Rollins College.

Dr. Knipp was keenly interested in experimentation and became extraordinarily skillfull in the techniques of manipulation. His 100 publications are predominantly reports of inventions or improvements in experimental methods or devices, or scientific conclusions which resulted fairly directly from such improvements. This inclination towards manipulation, combined with a considerable talent for showmanship, lead him to devote a good deal of attention to developing the art of lecture demonstration. His reputation as an interesting demonstrator spread far outside his classes, and he was besieged with invitations from educational and civic groups which he accepted as frequently as time permitted. This was his way of spreading a public appreciation of physics. A number of his inventions, notably the Knipp alpha-ray track apparatus, several discharge tubes, a nitrogen after-glow tube and the Knipp singing tube are widely used by physicists and constitute permanent contributions to the art of demonstration.

His scientific contributions clearly show the influence of his two sabbatical years, 1910-1911 and 1926-1927, at the Cavendish Laboratory in Cambridge, England, where he was associated with J. J. Thomson and Rutherford and whence he returned to this country to carry on the Cavendish tradition of research in conduction through gases and in radioactivity. One outcome of this work was a patent, jointly with the late Professor H. A. Brown, on an Alkali Vapor Detector Tube which was widely used and returned considerable royalties to the University.

Professor Knipp was responsible for the development of the course in electrical and magnetic measurements, known as Physics 44, and himself devised many of the experiments. He was also responsible for the functional design of the present Physics Laboratory which was completed in 1909.

He was a fellow of the American Physical Society and of the Ameri-

can Association for the Advancement of Science, a member of the American Optical Society, the American Institute of Electrical Engineers, the Society for the Promotion of Engineering Education, Sigma Xi, Phi Beta Kappa, the Indiana Academy of Science, and the Illinois Academy of Science, of which he was vice president in 1920 and president in 1921. His name was starred in the first and subsequent editions of American Men of Science. He was an active member of the committee on physics of the Century of Progress Exposition in Chicago in 1933.

Professor Knipp always took an active interest in community and university affairs. He served on the Urbana City Council from 1935 to 1943 and on several of its committees. He was secretary of the Board of Trustees of the McKinley Presbyterian Foundation.

In addition to having initiated many graduate and undergraduate students into the art of experimental and manipulative physics, Dr. Knipp always took a keen interest in their personal affairs, and he and Mrs. Knipp made their home a center of social life for many students.

Professor Knipp died on July 6, 1948. Surviving him are a son, Julian, Professor of Physics at Iowa State College; three daughters, Mrs. Max Shipley, Mrs. George Hill, a well known etcher, and Mrs. Paul Grote; a brother, Julius; a sister, Mrs. Illian Atkinson, and five grandchildren. Mrs. Knipp's death had preceded his by seven years.

Professor Knipp was an ingenious experimenter, a skillfull demonstrator, an enthusiastic educator of young men, a public spirited citizen, and a valued friend. His loss will be keenly felt in the world of physics and in the community.

(Signed) F. W. LOOMIS
H. H. JORDAN
F. B. SEELY

MARGARET ENGSTROM
1908-1948

Miss Margaret Elizabeth Engstrom, science teacher in Moline, Illinois, passed away on September 26, 1948. She was only 40 when cancer cut short her singularly rich and beautiful life.

Miss Engstrom received her early schooling in Moline. In 1927, when she entered Augustana College in nearby Rock Island, she was already an ardent student of the out-of-doors. In college, geology opened up a new world to her, kindling an interest which never became dimmed. As a college student she worked her way, and at various times served as laboratory instructor in both biology and geology. Handiwork that showed her skill as a preparator may still be seen in the college laboratories; and none of her science teachers is likely to forget the clarity and orderliness of her notebooks or the exquisite artistry of her pen and ink drawings. By extending her studies beyond the regular four years, she completed graduation requirements in both biology and geology, and became the first woman to major in the new department of geology. Subsequently she took postgraduate summer courses in botany at the University of Chicago.

At graduation in 1931, Miss Engstrom was appointed to the teaching staff of John Deere Junior High School, in Moline, her home city. Here she continued for seventeen years, the remainder of her life. During one year (1946-1947) she also taught geology at Moline Community College.

Miss Engstrom was a born teacher. One can hardly imagine her in any other capacity. For all her shyness and modest bearing, she was completely at ease with young people, who in turn understood and loved her. There was nothing superficial about Miss Engstrom's passion for nature; it glowed with clear, quiet intensity, and because it was so genuine it was contagious. Her thoughtful nature had deep undercurrents which she seldom expressed, either in words or writing, but of which all associates became aware. To these, therefore, it was not wholly a surprise when, after her death, a collection of poems of rare beauty came to light which she had written but never shown to anyone.

At John Deere Junior High School, an active Science Club came into being under Miss Engstrom's guidance. Through the years it developed many projects, including an excellent teaching museum; and its members accompanied Miss Engstrom every spring to the meetings of the Illinois Junior Academy of Science, where their exhibits regularly won high awards. In the Tri-

Cities, Miss Engstrom and her unfailing coterie of 'teen age boys and girls—often more than a score in number—were a familiar sight at every worth-while program or lecture relating to science, travel, or the out-of-doors.

Week-ends were devoted to field trips, and this was the activity which the members of the Science Club, and Miss Engstrom herself, enjoyed most of all. Probably no one knew the wooded ravines and upland prairies along this part of the Mississippi Valley better than this little teacher, who would set out with her devoted following, after school hours and on Saturdays, rain or shine. The field trips netted many fine fossils and other specimens for the museum. What was far more important, they left most of the students with a lifelong enthusiasm for natural history and the earth sciences.

Inevitably, from Miss Engstrom's Science Club came a steady stream of students who went on to higher studies in the various fields of science. At Augustana College, the Alma Mater to which Miss Engstrom was always loyal, year after year freshmen students—potential majors in biology or geology—presented themselves for registration with the simple but all-sufficient explanation that there were "Miss Engstrom's boys," or girls, as the case might be. They were always welcome.

In later years Miss Engstrom became an enthusiastic traveler, and during summer vacations visited Canada, Alaska, and most parts of this country. She returned repeatedly to her favorite western National Parks, her car filled with young people and their bulging bedrolls. In the spring of 1948 she became ill, but after treatments was again able to go west in the summer, to Wyoming. In September she participated in the opening conferences of the junior high school staff, but only for one day. The dread disease had recurred, and this time it ran a swift and fatal course.

Fifty active and alumni members of the Science Club have now founded "The Margaret Engstrom Society," which is pledged to continue Miss Engstrom's work and keep her ideals bright at John Deere Junior High School, by the establishment of various types of living memorials.

Miss Engstrom's home community will long recall her as a unique personality and one of the most gifted teachers in its history—and who would attempt to measure the significance of such a teacher to any community? Unnumbered men and women, her former students, hold Miss Engstrom in grateful remembrance. Many would thank her, if they could, because her gentle yet profound influence gave direction to their lives.

FRITIOF FRYXELL

ACADEMY BUSINESS

SECRETARY'S REPORT OF THE BUSINESS OF THE ILLINOIS STATE ACADEMY OF SCIENCE FOR THE YEAR MAY 8, 1948 TO MAY 7, 1949

Compiled by HURST H. SHOEMAKER,
Secretary

The 42nd Annual Meeting of the academy was held at Knox College in Galesburg on May 6 and 7, 1949. There were 103 papers presented in the nine senior and two collegiate sections to an attendance of about 675 persons. The annual banquet speaker on Friday evening was Dean Willard B. Spalding of the College of Education of the University of Illinois who spoke on "Training for Tomorrow's Schools." The 18 Illinois science talent search winners came to the platform to be introduced. The college or university to which each had won a scholarship was announced. Further carrying out the theme of science education was the address on Friday morning by C. W. Sanford, Director, Illinois Secondary School Curriculum Program, University of Illinois, who spoke on, "The Who in the High School Science Program." This theme was chosen in an effort to stimulate interest in the Psychology and Education section and to invite High School teachers to greater participation in the Academy of Science.

In regard to participation in Academy activities, the secretary has noted an indifference to the Academy on the part of some of our more prominent scientists. One of the reasons offered for this feeling is that publication in the *Transactions* does not carry the prestige of some of the national journals. One of the greatest values of the Academy is the opportunity offered to young scientists in getting experience in presenting their work at scientific meetings and in preparing it for publication. The privilege of encouraging these younger scientists is a service we should not lose sight of in deciding the value of the Academy. The nationally known scientists should consider their obligation also to meet with other scientists of the State and share with them their scientific advantages not possible to all, thus raising the general quality of Illinois science.

1. COUNCIL MEETINGS

The usual four council meetings were held during the year. President Paton presided over the first meeting in Benton May 8, 1948. Invitations for the 1949 meeting were discussed and the secretary was instructed to investigate them further and obtain formal invitations to be considered at the second council meeting. A policy regarding the release of back numbers of *Transactions* was presented and approved.

At the second meeting in Urbana October 9, 1948, the invitation to meet in Galesburg was accepted. After the duties of the committees were outlined by President Paton, reports were heard from the committee chairmen present. The Psychology and Education Chairman recommended that the section be dropped because of lack of interest. The council pointed out the Academy's responsibility to the science teachers of the state and decided to feature science education at the annual meeting in order to stimulate interest in this section. The officers of the Junior Academy met with the council until after arrangements for the annual meeting had been discussed. Mr. Porter presented a detailed report for the Junior Academy. As sufficient time did not remain to discuss the financial problem in relation to publishing the *Transactions*, the meeting as a whole was adjourned. In the afternoon a smaller group met to discuss this matter and estimated an amount needed for printing during the next biennium.

President Paton presided at the third council meeting January 15, 1949. Copies of the budget, the constitution, and forms to be used in the solicitation of papers for the annual meeting were distributed. A plan was approved for inter-office communication between the secretary, the treasurer, and the museum for keeping a better record of the changes in membership. After a discussion of the limitation to the length of

papers to be presented in the *Transactions*, the council felt that though eight printed pages should ordinarily be the limit, the acceptance of unusual longer papers should be left to the judgment of the editorial committee until further action.

Section chairmen gave progress reports on their plans for the annual meeting. Dr. Mills reported that conservation of the small natural areas had been the primary interest of his committee. He introduced George B. Fell, who had been doing a great deal of work on these areas, and who gave a detailed report of his activities. The council added Mr. Fell to the conservation committee and authorized him to represent the Academy at discussions in Springfield regarding the conservation of small areas.

The fourth meeting followed the council dinner on May 6 at Galesburg. There were 28 present with President Paton presiding. There were reports from the committees on budget, affiliation, conservation, and science talent search. Mr. Porter gave a report for the Junior Academy and indicated the desires of such companies as General Motors, General Electric, and Westinghouse to present exhibits at future annual meetings. Dr. Tehon reported for the publications committee and gave a brief report for the editor in her absence. Both Augustana College at Rock Island and the University of Illinois at Navy Pier extended cordial invitations to have the annual meeting of the Academy there in 1950.

PROGRESS REPORT ON THE ILLINOIS NATURAL AREA PRESERVATION PLAN

At the last annual meeting of the Academy, Dr. Mills presented a proposal for establishing a system of nature preserves in the State. The following resolution was passed at that meeting:

"Whereas, the State of Illinois is known to contain small natural areas distinct and precious by reason of their unique ecological features and rare species of plants and animals, and

Whereas, these areas are too small for inclusion in the State Park System as now visualized, and

Whereas, these areas are threatened with impairment or destruction by the inroads of industry, agriculture, or other developments, therefore:

Be it resolved, that the Council of the Illinois Academy of Science refer to the proper committee of the Academy the question of (1) finding some administrative state agency interested in the acquisition of such widely separated areas, (2) proposing some way of administering and protecting them, and (3) devising some method of selecting deserving sites, formulating specifications which the sites should meet, and assuring that the purpose for which the sites are set aside be actually preserved."

This report summarizes the work which has been done on the proposal since that time.

Publicity activities

(1) A circular letter was mimeographed on Nov. 29, 1948, and sent to about 500 persons including many Academy members.

(2) An outline of the main points of the proposal was compiled in February, 1949, on the basis of correspondence and consultation with a number of persons. Several hundred copies have been distributed. (See proposal for a System of State Natural Area Preserves.)

(3) Other organizations interested in conservation in Illinois have been contacted. These include the Conservation Council, Ecologists Union, Friends of Our Native Landscape, Illinois Chapter of Wildflower Preservation Society, Nature Study Society of Rockford, and others.

(4) Various State officials and agencies concerned with conservation have been contacted regarding the proposal.

Information accumulated

(1) A list of Illinois natural areas in need of preservation has been begun. To date the list includes 53 areas, but is incomplete in regard to areas cited and details concerning them.

(2) Information has been accumulated concerning natural area preservation activities elsewhere. Projects similar to the Illinois plan have been begun in Wisconsin and Michigan. The Iowa Academy of Science has sponsored a program to preserve prairie tracts in that State. The Society of American Foresters has a natural areas committee dedicated to the preservation of at least one example of each forest type in the United States. The Ecologists Union is an organization recently formed to promote the preservation and study of natural areas. The Wilderness Society has adopted a policy of support in the preservation of small "wildland patches." There is news also of similar programs in many other countries.

(3) The legal and administrative problems involved in establishing the proposed

system in Illinois have been studied. The division of responsibility for conservation matters in the State government is the main problem which must be faced. At least the following agencies have fields of interest which border on this plan: the Division of Parks and Memorials, the Department of Conservation, the Natural History Survey, the State Museum, and the University of Illinois. Of these the Division of Parks and Memorials and the Department of Conservation are the primary land-holding agencies. The Division of Parks and Memorials already has the legal authority to acquire areas of this sort. However, it would be preferable to have enabling legislation specifically restricting the use and development of tracts acquired as nature sanctuaries.

Now let us return to the resolution passed last year by the Academy. In it are several questions which have been partially but not completely answered.

Question 1. Finding some administrative State agency interested in acquisition of such widely separated areas, has been defined but not finally settled.

Question 2. Proposing some way of administering and protecting them is tentatively answered in the outline referred to above.

Question 3. Devising some method of selecting deserving sites, formulating specifications which sites should meet, and assuring that the purpose for which the sites are set aside be actually preserved. The first two points (method of selecting sites, and specifications) have been answered, but actual selection of areas awaits the availability of sufficient funds to finance a survey. The suggested restrictive enabling legislation would solve the problem of assuring proper use of the tracts.

Further action

Further educational and publicity activities are necessary. Contacts thus far have been restricted to persons thought to be interested in such a program. The larger State organizations such as the women's and sportsmen's clubs as well as the general public should be made aware of the problem. State officials and legislators need to be further acquainted with the plan.

The Academy can broaden its activities on this project if it so desires. A possible program, but one which would require a large amount of work, might be to sponsor a campaign for funds either to make an inventory of natural areas in the State or to acquire areas to be turned over to the State. Such action would tend to produce more respect for the program and make it easier to acquire support of the State government.

There seems to be no doubt that this problem of preserving natural areas is of great immediate importance. Richard Pough of the American Museum of Natural History writes, "There is no question but what it is the number one conservation job today, outside the field of conservation of exploitable economic resources."

In conclusion, the urgency of this matter cannot be stressed too strongly. The remaining natural areas in the State are disappearing very rapidly. Pressure for increased production of food and wood products and residential construction, as well as modern technological developments have destroyed one after another of these strongholds of nature in recent years. It is much easier to obtain information about areas which existed until recently than it is to find areas which still remain.

May 5, 1949

PROPOSAL FOR A SYSTEM OF STATE NATURAL AREA PRESERVES

I. *Definition:*

Natural Area Preserves shall be tracts of land having distinctive natural features worthy of preservation for scientific, educational, and esthetic reasons. These include areas having unusual plant or animal life or geological features and areas having remnants of the original vegetation which has not been disturbed by the activities of man.

II. *Purpose:*

A. *Scientific:* Research in the various fields of land management (agriculture, forestry, wildlife) involves the use of undisturbed areas for comparative purposes, as scientific control or check areas. Scientists in many fields of biology, such as ecology and taxonomy, also make use of such areas.

B. *Educational:* These areas are valuable in teaching a proper understanding of the land upon which we live and are dependent. They would be useful for field trips by school children and others.

C. *Esthetic:* These areas would preserve the last remnants in the State of many na-

REPORT OF THE TREASURER

For the Year May 1, 1948 to April 30, 1949

Balance on hand April 30, 1948	$ 2,011.58	
Less oustanding checks April 30, 1948	423.57	
True Cash Balance		$ 1,588.01

Receipts

Dues:		
Annual members	$ 1,289.00	
Life member	50.00	
Affiliated societies and clubs	27.00	
		1,366.00
Cash for Certificate on Forbes Building		311.31
Interest on Meyer Block Leasehold		4.50
Interest on Series G Bonds		17.50
Sales of Reprints		233.70
Sales of Transactions		72.50
Libraries		6.00
Research Grant from AAAS		260.50
Junior Academy-Sustaining Memberships		240.00
Total Receipts		$ 4,100.02

Expenditures

Council Expenses	$ 49.32
Section Chairmen's Expenses	15.31
Treasurer's Office Expenses	121.51
Secretary's Office Expenses	134.51
Editor's Office Expenses	17.69
Librarian's Expenses	154.93
Printing	221.15
Conservation Council	3.00
Secretary, Honorarium	150.00
Editor, Honorarium	150.00
Research grants	260.50
Purchase of back volumes of transactions	36.00
Purchase of 13—Series G Bonds	1,300.00
Junior Academy	439.38
Total Expenditures	$ 3,053.30
Less outstanding checks	4.81
	$ 3,048.49
Balance in Commercial National Bank of Peoria	1,051.53
	$ 4,100.02

Statement of Resources, April 30, 1949

Balance in Commercial National Bank of Peoria	$ 1,051.53
Certificate of Interest for Meyer Block Leasehold	Value Unknown
United States Savings Bonds, Series G	1,500.00
Total Resources	$ 2,551.53

(Signed) W. W. Grimm, *Treasurer*

tive plants and animals, including such flowers as orchids and gentians. They would serve as "living museums" of untouched or unusual remnants of the natural Illinois landscape for future generations to study and enjoy.

III. *Plan:*

A. *System of administration:* A State operated system shall be established to locate, acquire, and maintain natural areas as Natural Area Preserves.

B. *Size of areas:* These preserves shall be of any suitable size. In most cases they shall include only a few acres.

C. *Restriction of use:* These preserves shall not be developed for recreational use of for the production of a crop such as timber or game.

IV. *Administration:*

A. *Acquisition:* Preserves shall be acquired by donation or purchase.

B. *Management:* Preserves shall be maintained in as primitive a condition as possible. Ordinarily management would include fencing, fire protection (in some situations), and posting with appropriate explanatory signs. The project should be explained to adjacent landowners and to organizations and clubs in the vicinity; and scientific records should be compiled for the areas. Because of the absence of improvements and the small size of the tracts, no resident custodians shall be necessary.

C. *Relation to other public lands:*

1. *Distinction from other public lands:* These preserves shall be limited to areas which are of greatest value if left undisturbed except for study and observation. They shall be distinctive from State parks which are of value for recreational purposes and from State forests and wildlife areas which are of value for timber and game production, respectively.

2. *Preserves within other public lands:* Portions of other public lands may, by cooperative agreement with the administrative agency thereof, be designated as Natural Area Preserves, when these portions would be of greatest value if so designated and restricted.

D. *Advisory board:* There shall be an advisory board consisting of three professional biologists appointed by the Governor.

V. *Basis of proposal:* Organizations actively endorsing this plan include the Illinois State Academy of Science, the Conservation Council, the Ecologists Union, the Friends of our Native Landscape, and the Illinois chapter of the Wildflower Preservation Society.

REPORT OF THE COMMITTEE ON AUDITING

To The Illinois State Academy of Science:

Your committee on auditing respectfully submits the following report:

We have examined the records of the Treasurer, W. W. Grimm, for the year May 1, 1948 to April 30, 1949, and find them correct. The present financial status of the Academy is as follows:

Cash on deposit with the Commercial National Bank of Peoria	$ 1,051.53
Series G, U.S. Savings Bonds, fifteen	1,500.00
Meyer Block Leasehold Certificate No. 15 (value unknown)	0.00
ASSETS	$ 2,551.53
Less Outstanding Checks	4.81
Real Assets	$ 2,546.72

We saw the evidence of purchase of $1300 Series G Bonds in the name of the Academy, but did not verify the Treasurer's possession of the securities listed above.

(Signed) ALLAN K. SMITH *Chairman*,
A. G. ADAMSON
F. W. LUTTEY

REPORT OF THE COMMITTEE ON RESOLUTIONS

I. A Resolution Regarding the Preservation of Small Natural Areas and the Establishment of Nature Preserves

Whereas: (1) the State of Illinois is known to contain small natural areas distinct and precious by reason of their unique ecological features and rare species of plants and animals, and

Whereas: (2) these areas are of little value for public recreation, and

Whereas: (3) these areas are threatened with impairment or destruction by the in-

roads of industry, agriculture or other developments, therefore

Be is resolved: that the Illinois State Academy of Science favors establishment by the State of Illinois of a system of Nature Preserves, for educational and scientific purposes, such as will result in preservation of these areas as sanctuaries and a heritage for future generations.

II. A Resolution Regarding Deceased Members

Whereas: Death has removed from our group the following valued members of the Academy:

John Haynes Bailey
James W. Bristow
Charles K. Carpenter
Margaret E. Engstrom
Albert K. Epstein
E. H. Ehrman
Charles T. Knipp
Frank R. Lillie
C. E. Parmenter
Frederick B. Plummer
Douglas F. Stevens
Eleanor C. Smith
Isabel S. Smith
J. E. Trieschmann
Edgar J. Witzemann
James G. Wray

Be it resolved: (1) That the Academy expresses its grief over their passing, and

(2) That it extends its sincere sympathy to their families, to whom the Secretary is directed to write letters indicating our sense of loss while we extend our sincere sympathy.

III. A Resolution in Appreciation of the Annual Meeting Arrangements

Whereas: Under the present difficulties of crowded facilities, the City of Galesburg, the College, and the State University Division, the High School, the Hotels, and numerous individuals have contributed to a very successful annual meeting of the Academy.

Be it resolved: (1) The Academy extends its sincere appreciation of all of the efforts put forth in its behalf to

The City of Galesburg, The Galesburg Board of Education and Superintendent Lindsey, the Galesburg Press;

Knox College, its Acting President, Mr. McClelland, and its Dean, Mr. Willhite;

The University of Illinois—Galesburg Division, its Executive Dean, Mr. Louttit, and members of his staff;

The Managements of the Hotel Custer and the Broadview Hotel;

The Senior High School, its Principal, Mr. Wooley, and many members of his corps of teachers; and

The Committee on Local Arrangements, composed of Mr. Reed, Chairman, Mr. Aitchison, Mr. Bowen, Mr. Bumstead, Mr. Conklin, Mr. Fiala, Mr. Furrow, Mr. Gilbraith, Miss Hatch, Mr. Neifert, Mr. Elroy Smith, and Mr. Walton.

(2) That the Secretary be instructed to convey this appreciation in writing to each of the above named institutions and Committees.

(Signed) A. C. WALTON, *Chairman*
GEORGE B. FELL
L. R. TEHON

STATE OF ILLINOIS

ADLAI E. STEVENSON, *Governor*

TRANSACTIONS

OF THE

ILLINOIS STATE ACADEMY OF SCIENCE

VOLUME 43 1950

Forty-Third Annual Meeting

Rock Island, Illinois

May, 1950

PRINTED BY AUTHORITY OF THE STATE OF ILLINOIS

ILLINOIS STATE ACADEMY OF SCIENCE

AFFILIATED WITH THE

ILLINOIS STATE MUSEUM DIVISION, CENTENNIAL BUILDING

SPRINGFIELD, ILLINOIS

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ADLAI E. STEVENSON, *Governor*

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DECEMBER 31, 1950

STATE OF ILLINOIS
ADLAI E. STEVENSON, *Governor*

DEPARTMENT OF REGISTRATION AND EDUCATION
NOBLE J. PUFFER, *Director*

ILLINOIS STATE MUSEUM DIVISION
THORNE DEUEL, *Chief*

ILLINOIS ACADEMY OF SCIENCE

AFFILIATED WITH THE
ILLINOIS STATE MUSEUM

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1949-1950

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CONTENTS

PAGE

ADDRESSES

DEUEL, THORNE, A New Approach to Studies of Culture and Society .. 9
BERGENDOFF, CONRAD, Welcome to Augustana .. 16
LEIGHTON, MORRIS, M., Dedication of Lindahl-Udden Memorial .. 19
BAILEY, WILLIAM M., The Beginning of the Illinois State Academy of Science ... 24

PROGRAM

Papers Presented at the 43rd Annual Meeting .. 34

BOTANY

FULLER, GEORGE D., The Lignecus Flora of Richland County, Illinois, by Robert Ridgway, an Unpublished Manuscript .. 40
STEWART, WILSON N., The Carr and Daniels Collections of Fossil Plants from Mazon Creek .. 41
KAEISER, MARGARET, Microscopic Anatomy of the Wood of Three Species of Junipers .. 46
SCHULDT, ERICH, AND DAVID GOTTLIEB, Colchicine as a Mutagenic Agent for *Streptomyces griseus* .. 51
DAMANN, KENNETH E., A Simplified Plankton Counting Method .. 53
HUBBARD, C. V., AND H. H. THORNBERRY, Utilization of Some Organic Acids by *Streptomyses griseus* for Streptomycin Production and Growth .. 61

CHEMISTRY

YOHE, G. R., DONALD R. HILL, AND HOWARD S. CLARK, Methoxyl Determinations on Alkyl Esters of 2-Methoxybenzoic Acid .. 75
THIESSEN, G. W., The Kolbe Electrochemical Synthesis .. 77
GREEN, FRANK O., AND BERNARD G. JACKSON, A Spherical Arrangement of the Chemical Elements .. 83

GEOGRAPHY

YAHR, CHARLES C., Geographical Possibilities of Cork Production in the United States .. 91
HUDSON, H. E., Water Resource Conservation in Illinois .. 101
CALEF, WESLEY, Slope Studies of Northern Illinois .. 110

GEOLOGY

FRYXELL, FRITIOF, Student Projects and Their Place in Geologic Education .. 116
CHAPMAN, CARLETON A., Some Easily Constructed Models for Teaching Optical Mineralogy .. 121
HENDERSON, DONALD M., Atomic Models of the Silicates as an Essential Aid in the Teaching of Elementary Mineralogy .. 127
BRETZ J HARLEN, Glacial Lake Merrimac .. 132
RAASCH, GILBERT O., Current Evaluation of the Cambrian-Keweenawan Boundary 137
TEMPLETON, J. S., The Mt. Simon Sandstone in Northern Illinois .. 151
GRAF, DONALD L., Petrology of Basal High-Purity Bed of the Burlington Limestone .. 160
HENDERSON, DONALD M., Metamorphic Development of the Crawford Notch Quadrangle, New Hampshire .. 165
HORBERG, LELAND, Preglacial Gravels in Henry County, Illinois .. 171
WORKMAN, L. E., The Neda Formation in Northeastern Illinois .. 176

PHYSICS

Bonvallet, G. L., Survey of City Noise 183
Huxford, W. S., and H. N. Olsen, Spectral Characteristics of Flash Discharges 189
Roberts, Howard C., Optical and Photographic Techniques for the Small-School Laboratory 196

PSYCHOLOGY AND EDUCATION

Kinney, Elva E., Validation by Means of the Sociogram of a Technique for Promoting Social Acceptability Among Elementary School Children 202
Bullington, Robert A., A Study of College Science Courses Designed for General Education 209

SOCIAL SCIENCE

Wray, Donald E., Sociological Problems in the Study of Industrial Relations in Illinois 213
Jaffe, Grace M., The Relative Powers of Nature and Nurture: Monozygotic Twins 218
Johnson, Joseph K., The Need for Corporate Research in the Social Sciences.. 224

ZOOLOGY

Levine, Norman D., The Use of Horse Strongyle Larvae in Screening Compounds for Anthelmintic Activity 233
Foote, Charles L., and Florence M. Foote, A Comparative Study of Normal and Piebald Hamsters 237
Balduf, W. V., Problems in the Bionomics of the Squash Bug, *Anasa tristis* (De Geer) 244
Long, E. J., Ecological Notes on *Thanatophilus americana* L..... 249
Wantland, Wayne W., Mary Ho, Mildred M. Carmichael, and Clifford Storm, An Investigation of the Occurrence of *Enterobius vemicularis* Ova in Dust from Homes and Public Buildings 253
Wantland, Wayne W., Seije Nakada and Hubert Engel, The Incidence of *Endamoeba gingivalis* in a Central Illinois Community..... 256
Tahmisian, Theodore N., and Austin M. Brues, A New Method for Staining Cells with Cobalt and Bal..... 259

COLLEGIATE SECTION

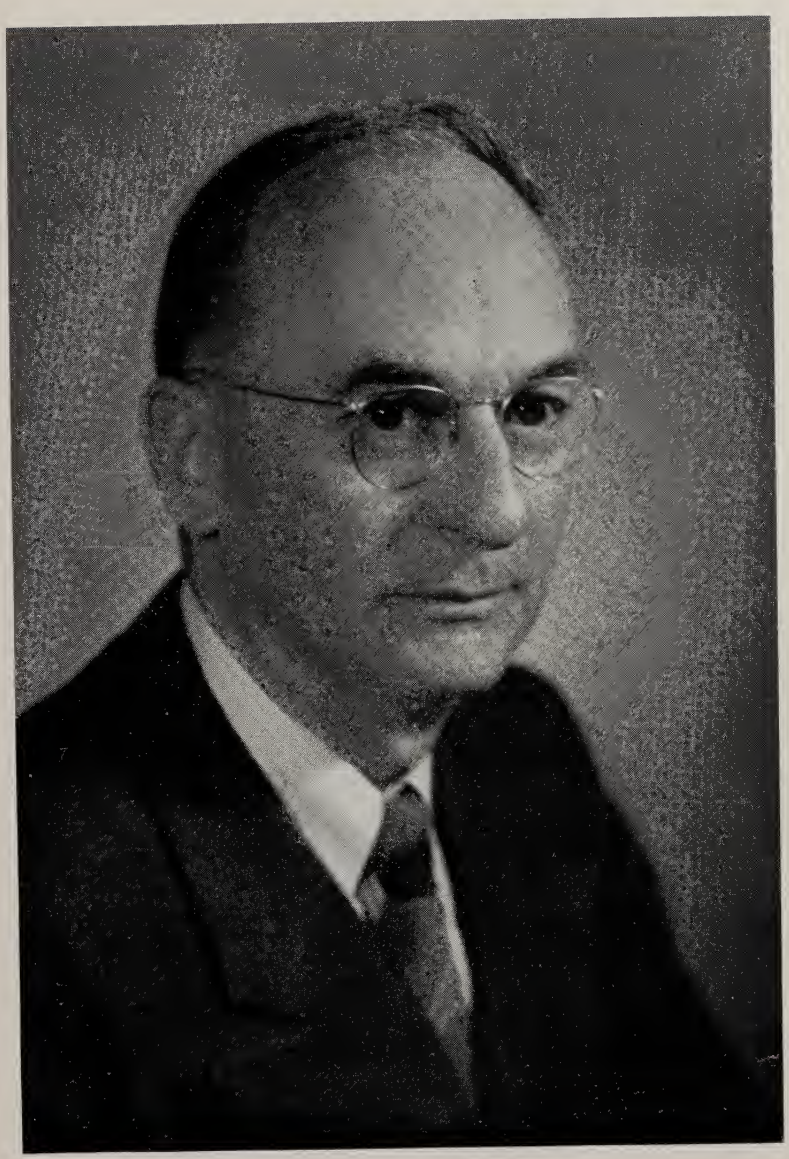
Bresingham, Dolores, The Study of Cicatrization in Plant Tissues..... 261

MEMORIAL

Neil E. Stevens 265

ACADEMY BUSINESS

Secretary's Report for 1949-1950..... 267
New Constitution and By-laws..... 272



THORNE DEUEL, *President,* 1949-1950

PRESIDENTIAL ADDRESS

A NEW APPROACH TO STUDIES OF CULTURE AND SOCIETY

THORNE DEUEL
President, Illinois State Academy of Science

When I began some months ago to draft an outline for this paper, I was already engaged in writing a booklet in the *Story of Illinois* series of the Museum, called "Man's Venture in Culture" with the subtitle "Some Inventions Underlying Modern Civilization in Illinois." Work on this pamphlet set in motion a train of thought and raised questions that, I suppose, have always puzzled students of man. How was man launched on his cultural and social career and, once started, what kept him on the road? Is culture haphazard and erratic? Is it, as Professor Lowie once said, "a thing of shreds and patches"? Or does it have direction and meaning?

If I seem dogmatic, I hope you will consider that my statements are always qualified by the phrases "in my opinion" or "it seems to me."

The talk you will hear is selected from a larger paper and will consist of three parts:

(1) A broad hypothesis of cultural and social evolution.

(2) A brief survey of man's essential needs and his means of satisfying them as a starting point for studies in culture and society.

(3) A comparison of the means used to satisfy the same need in a simple culture and in the United States today.

Cultural and Social Evolution

For several hundred years, philosophers, historians, and, more lately, scientists have observed, experimented, and amassed vast amounts of data about man, his psychological nature, his cultural and social achievements. The resulting conclusions, even where they deal with significant data, have been disappointing. Consideration of this state of affairs seems to indicate a need for a new approach to the sciences concerned.

It seems almost obvious after considerable reflection on the subject that man's existence may be divided into four periods or stages of cultural and social development, each bounded or limited at beginning and end by a discovery and invention series. Whether or not the individual should be considered as man or wild animal in the first stage is outside this presentation.

Whether or not he should be considered a man in the first stage, he *did* learn to stand up on his hind legs, to walk about in the upright position, to use his hands (instead of his jaws) to seize food and to convey it to his mouth, to throw stones and hit with sticks in self-protection or aggression, and finally to crack rocks and break sticks so that they would better serve his purposes.

Finally he hit upon a discovery—the realization that if he struck a piece of flint in a certain way with a small boulder he always got the same result, a shell-shaped (conchoidal) scar on the rock mass or core. He next visualized how to make a weapon of a certain shape by using his discovery, possibly years afterward, though I am inclined to believe the invention followed close upon the discovery. At any rate he eventually invented a chipped stone tool the type of which was copied again and again. Archaeologists recognize some of his improved types of early stone tool as a fist axe or a chopper.

I shall follow him briefly through the second stage in which he became a family man, learned to talk, and formed loosely knit societies with other men, hunted animals with groups of his fellows, until finally the woman discovered how to grow food plants at home and the man to bring up young animals found during the hunt, to tame and breed them in captivity.

This led man into the age of food production where the family raised their own grain and meat, which was thereby generally more plentiful and certain. He could support larger families than before and live in villages, where he now needed to cooperate with his neighbors and to devise a means of regulating the conduct of families thus living side by side. It was probably the man who had the idea of hitching the bullock or cow to the digging stick that the woman used and thus invented the plow. Over the centuries that followed, food production was accelerated, cities grew, and government and religion became complicated. Man learned to hitch the ox to the mill to grind his corn, or to a wheel to lift water from the river to his fields. The latter part of this stage we usually call ancient history.

Shortly before the beginning of the Christian era man made his third key discovery—that a wheel turned by the power of water could be hitched to his mill and do more and better work than his tame animals. Roughly this coincides with the beginning of Mediaeval and Modern History. I shall not go into the changes that have taken place since that discovery; they are fully described in histories. And it is well known that atomic energy is the latest source of inanimate power man has attempted to harness to the machine.

To summarize, there have been, if my hypothesis is correct, three key discovery-inventions: (1) the discovery that stone could be regularly chipped or flaked and thus tools be made of useful, specialized shape, (2) that plants and food-draft animals could be bred and raised successfully in artificial surroundings, and (3) that inanimate power could be harnessed to machines to do work man had never dreamed of doing before.

The four stages can be called: (1) the brute or pre-cultural stage, (2) the stage of man's self-domestication, (3) the stage of food production, and (4) the machine age or stage of mass production.

Man's Essential Needs

Now let us look at some of man's needs which we can, I believe, agree upon as essential or basic needs. We shall have to disregard, perhaps, for the time being some of our standards of value that we have learned to consider significant. Possibly some of them may be the means of satisfying needs (and not very important ones

at that) rather than actual needs. It may help us in our attempts to separate needs from the means of satisfying them to consider a principle generally accepted among social anthropologists: a going cultural and social group continues to so exist because it provides the means of satisfying the essential needs of the individuals of that group.

The basic needs of man in a cultural and social world and some of the means of satisfying those needs at one period or another of his existence are listed in table I.

TABLE I.

Basic Needs	*Means of Satisfying Needs*
1. Individual security.	1. Pursuits that permit individuals to secure food, water, air, sunlight, housing, clothing. Magic, religion, ethics, science, technology, values, law, order, philosophy and ethics.
2. The opportunity for the individual to develop and fit himself into his surroundings.	2. Curiosity and cautiousness, play activities, education, experience, professional and technical training, clubs, societies, associations, art, literature, theatre, and similar pursuits.
3. Lineage and group continuation.	3. Marriage and marriage customs.
4. Regulation of individuals within groups, and of groups with individuals and other groups.	4. Custom, law, government.

The first three of these are equally the needs of all living things, the last seems to apply to the so-called gregarious and social animals. However, the cultural and social means of satisfying man's needs appear to be of a different kind, possibly best expressed by saying that they exist chiefly on a cultural and social level as against the purely instinctive level of non-cultural animals. Accompanying the needs and the means taken to satisfy them—in fact, the chain on which the needs (instinct or tendency to act) and the means (action or behavior) are strung—is the healthy activity or functioning of the nervous organization. These needs and, to a greater or lesser degree, the identification and acceptance of the means to satisfy them lie in the nervous and physical structure that offspring inherit from their ancestral lineage through their parents. In the multiplicity of details (important to the individual on account of his standards of values concerning his cultural and social surroundings, though not necessarily significant in the eyes of his group or to cultural and social evolution), the means differ widely.

You may think of other needs, but I believe you will agree that those proposed are essential to man today in his world. Individuals, of course, may exist who apparently disregard certain of the basic needs but they are overwhelmingly in the minority and are not important for our discussion nor in cultural evolution.

A Means of Social Regulation

Let us now take a basic need of man and one of the means devised

or invented to satisfy it—the need and means for regulation and guidance. We could equally well have chosen another need and the corresponding means of satisfying it. Whenever the domestication of plants and/or animals was discovered or wherever the invention was learned and put to use by man, sooner or later a number of families gathered and formed communities. Man as a member of such groups found it to the advantage of himself and his family to have a simple regulatory system to give security and equal rights to all families in the village and to protect them from outsiders. Without going into the history of governmental forms, I believe we can classify them all into two broad types, which may be called *the rule of the majority* and *the rule of the minority*. The governments of the United States, Great Britain, and Switzerland belong to the first class; the ancient oriental and mediaeval kingdoms and empires, Russia, and "dictated republics" to the second. It is beside the point to discuss here the relative merits of the two types. From an anthropological standpoint, whichever one works satisfactorily for a group is for that people at that time a healthful way of satisfying their need in this respect.

On account of our interest and general acceptance of its value in the United States, we shall consider here government by the majority or democracy. From our knowledge of man from history and ethnology, it is probable that the earliest villages were governed by a council of all the citizens meeting in assembly. Similar communities in the same cultural stage exist today. Their citizens' councils bear a close resemblance to the New England town meeting. If we examine the significant features of these early third or food production stage democracies we find:

The citizens assemble at the announcement of messengers, or perhaps a town crier announces through the streets the business to come before the assembly. The citizens meet at the appointed hour. A chairman, elected for the purpose, or possibly for the year, calls the meeting to order, puts or calls upon others to put each item of business before the gathering. All citizens are permitted to speak freely about the matter, whether they favor or oppose the issue. At the end of the discussion of each question, a *viva voce* vote is called, first those in favor saying "aye," then those against it saying "no." It was a simple matter to decide, according to the volume of response, which side had won as long as opinion was heavily weighted one way or the other. It was impossible to decide when the assemblies were large and almost evenly divided on an issue, for these early people were unable to count. When villages grew into cities or became countries with considerable outlying territory, these simple democracies were unable to survive and minority rule of the kingship type became the order in western and southern Asia and northern Africa, and later in Europe and most of Africa.

If we were to study the Greek city-states, the Roman and the Swiss republics, we would see how these difficulties of regulating dense populations and extensive territories were gradually overcome and government by the people made practicable under changed conditions. However, let us look at our own United States (table IIb). We in the United States of America believe our form of regu-

TABLE II.

a. *Primitive Village*	b. *United States*
1. The citizens of the village are the governing power, that is they make laws, arrange for their enforcement, punish violators and defend their community.	1. The citizens of the country are the governing power or the source of that power. Men and women over 21 years of age and mentally competent are citizens.
2. The village assembly consisting of all citizens performs the functions of an executive, legislative, and judicial nature, and elect a leader during emergencies.	2 In general the citizens elect by ballot officers and members of legislative and judicial bodies to act for them by performing executive, legislative, judicial, and defense functions in accordance with the general wishes of the electing citizens for a definitely limited term of office. These officers and representatives are responsible to the citizens electing them whether or not they so think and act.
3. The assembly elects a leader to act temporarily for the village in a crisis. He vacates his office and duties when the emergency is over.	3. The powers of certain offices are expanded and/or new officers are appointed in an emergency, for its duration only, after which these powers and offices are reduced again to their usual peacetime limitations.
4. Information is freely exchanged among villagers. Issues are discussed on the floor of the assembly. Minority views are heard equally with all variations of opinion, without restraint or threat of injury.	4. Information untampered with by those temporarily exercising the governing functions is communicated to the citizens by means of newspapers, radio, books, magazines, and other means, so all sides of issues may be known, including international relationships, domestic issues and happenings, and scientific discoveries.
5. Decisions of the assembly are arrived at by *viva voce* voting of qualified voters regardless of which side of the issue they take. Views of the majority are accepted by all and carried out.	5. Decisions are secured in the different governing bodies and the elections by *viva voce* voting or balloting of all qualified voters attending the polls or duly authorized meetings. The minority votes without fear of injury or restraint and the will of majority is accepted by all and carried out.

lating and guiding people's conduct to be as good as, or perhaps a little better than, any other form of control in the world.

There are differences between the tremendously complex organization of government by the majority in the United States today and the very simple democratic form back in western Asia nine or ten thousand years ago. I believe it is not difficult to explain those differences between the two political units in terms of population density, extent of territory, modern complexity of the technological devices and the diversities of the social organization and of thought. Comparing the corresponding features of the two democracies:

(1) The first item is essentially the same in both simple and representative democracies (the governing power rests with the citizens).

(2) In our United States, government by representation is neces-

sary (we know no substitute) because of the enormous number of people and the vast extent of territory involved. How citizens are considered qualified is not very important as long as it is done on a reasonable basis and is acceptable to the group.

(3) In the primitive democracy the headman, or someone elected by the assembly of citizens, would take over in an emergency. In modern democracies it is simpler to increase the powers of officers already functioning although additional officers are also appointed for special work not considered necessary in ordinary times.

(4) Methods of communicating information have changed enormously since the early village democracies through technological inventions, but our present methods serve the same purpose of getting the news promptly to the citizens, now numbering in the millions and scattered over millions of square miles.

(5) Voting *viva voce,* by ballot or by balloting machines, today takes advantage of technological inventions to insure accuracy of results, to speed up the "returns" from millions of people over a wide area. The purpose is still to determine the will of the majority of the citizens, which is accepted by all.

Let me see if I can simplify into single phrases each of the parallel items so that one statement may satisfy the essential principles of a democracy at any time.

1. The governing power resides in all the citizens.
2. The local body of citizens directs the regulatory processes either directly or through representatives elected by them. Issues are discussed and voting on either side of issues is done without fear of injury or threats to intimidate.
3. In times of emergency, officers with special powers may be elected and/or the powers of those in office may be expanded during the crisis only.
4. Information giving both sides of issues is circulated without being colored by officials in office.
5. Each question is decided by the majority of the voters, voting being done in a manner suitable to the conditions of population and territory. The will of the majority is accepted by all.

Summary

Without wishing to belabor my point, it seems to me that a new approach, or a revised approach if you like, is in order in the social sciences.

My proposal is that studies should be made of the essential needs of man and the means of satisfying them in different autonomous cultural and social groups. I suggest the studies be made in the different stages suggested above because I believe such stages exist and are basic in cultural and social evolution. Comparison of suitable (that is, as nearly complete) examples of the means as possible in each stage will, I believe, insure determination of significant features of those means. The significant series of the means satisfying each need in all the stages should be compared again one with another. The result, I believe, in each case will be an identity or near-identity, provided a corresponding means has developed or continued in

each stage considered. The differences, I am confident, will be found in man's increasing means of satisfying his needs, in the changing from one means to another deemed more serviceable, in the changing, over long periods of time, of certain means into needs, and in changes in man's natural and artificial surroundings.

In pursuing the research referred to it will be necessary for the worker to strip from the means of satisfying the essential needs any nonsignificant features, as one who in reorganizing his attic removes the rubbish.

The two fields of psychology and cultural social studies are, of course, closely linked. Nevertheless, it may be possible, after clearing away some of the confusion, to study the psychological processes separately from the cultural and social processes.

WELCOME TO AUGUSTANA

CONRAD BERGENDOFF
President, Augustana College, Rock Island

More than the historians of American education have yet made clear, our schools have received stimulus and contributions from older systems of other countries. Augustana is an illustration of this fact. Seventy-five years ago its faculty was made up almost entirely of men trained in higher schools of Sweden. In 1876 the Swedish government took part in the Centennial Exposition in Philadelphia, and Augustana had the good fortune to secure for its faculty the secretary of the Swedish section, Josua Lindahl, who had his doctor's degree from and had been a teacher at the University of Lund. With his arrival in 1879 the foundations were laid for the natural sciences on this campus. I find in the catalogue of a decade later these statements of how the sciences then were taught here.

Freshman Year:

Botany—Vetegable Histology: Examination of the various kinds of plant tissues; microscopic work; Lectures and Recitations. Vegetable Physiology.

Vegetable Taxonomy—detailed examination of types of respective groups. Martin's *Human Body* was used as a text.

Sophomore Year:

Physics, General and Analytical Chemistry.

Junior Year:

Physiology: Dissection of parts of vertebrate animals to illustrate human anatomy and histology.

Conchology: Study of the specimens in the Lindahl collection of mollusca with a view to identification of genera and families.

Senior Year:

Geology: Lectures and Recitations. Exercises in identification of the more common fossils, minerals and rocks: Four excursions to the nearest exposures of the Quaternary, Carboniferous, Devonian, and Silurian formations. The text was Le Conte's *Elements of Geology.*

I am not competent to compare such a scientific curriculum with that of other American colleges 70 years ago, but I am impressed with the emphasis laid on observation, experiment, student collecting and handling of data, and the division of the material. Still another item of interest was the building and use of the museum. Here a word may be in place concerning Josua Lindahl's contribution, not only to Augustana but to the State of Illinois. As a student Lindahl had worked with the museum at Lund University, and for three years he had served as assistant in the Royal Museum at Stockholm under one of Europe's foremost curators. He had set up the Swedish exhibit at the International Geographical Congress in Paris in 1875, and the following year had the similar assignment at Philadelphia. So it was natural that one of his objectives at Augustana would be the establishment of a good collection.

Here is an extract from the Catalogue of 1886-7.

The Curator spent two months of last summer on the Pacific Coast collecting specimens on the Farallon Islands—a number of interesting duplicates of the collections of the California Academy of

Science were liberally given to him with the prospect of future returns in Illinois specimens—of the lichens collected on the Farallones and in Southern California, which were subsequently sent to the eminent Swedish botanist, Dr. J. Hulting of Norrköping, Sweden, for determination, a series of 16 named species was lately returned to the museum by Dr. Hulting, who had most kindly further increased the collection by adding 17 species of Swedish lichens—a set of fragments, comprising 350 species of minerals and rocks have been purchased from Prof. A. E. Foote of Philadelphia—a card catalogue of the contents of the museum is being prepared. Thus far only the *Testudinata* and *Ophidia* are completed, while the other vertebrates, the crustaceans and the worms, are still under operation. Notwithstanding the present crowded quarters of the museum, it is made available for study, and besides a constant use of specimens in the regular classwork, special studies of various branches of the collections have been made by several students.

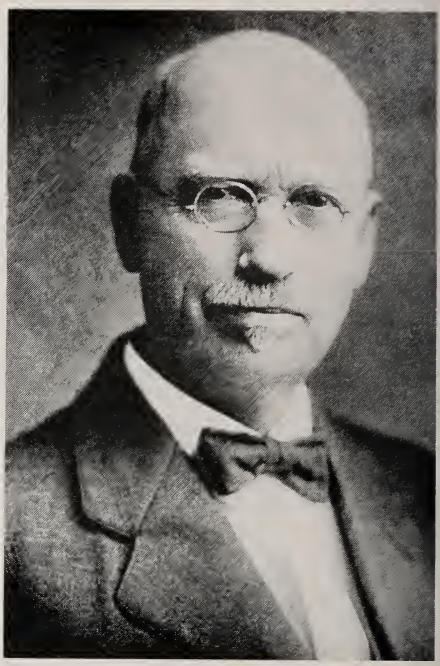
In 1888 Dr. Lindahl moved to Springfield, on his appointment as Curator of the State Library and Museum.

It is not my intention to impose on you a history of the sciences on this campus. But we want you to know that you come to an institution which is interested in your work. I take it that Augustana's origin as a church institution is known to you, and there may be some who wonder if religion and science have been friends here. May I assure you that throughout its 90 years they have been closely related, and that there has been no controversy between them. I have mentioned Josua Lindahl because he typifies the spirit of this campus in this matter. Himself a minister's son, he argued for a close alliance between the teachers of science and the teachers of religion for the good of both.

I like to think that there was a relationship between Lindahl and that great Swedish botanist, Linnaeus, whose devotion to science none would question and whose motto was the words of Ovid, "Innoque vivito, Numen adest" (Live without reproach, God is present). The tradition in which Lindahl worked—and which he transferred to this campus—gave to the facts of the physical universe a significance which derived from more than human reason. A biographer of Pascal has described the parallel interests in the words "laboratory" and "oratory"—in the older sense of that word, namely prayer. To know the world in which man lives, to know the God to whom man prays, this seems to us to encompass a liberal arts education. Therefore religion and philosophy as well as the natural sciences are free on this campus to bring their own methods and insights to the complete training of American youth.

In that spirit we welcome the Illinois Academy of Science to hold its 43rd Annual Meeting in our halls, hoping together with you to realize the fellowship and good will wherein truth may flourish.

Josua Lindahl



Johan August Udden

The Lindahl-Udden Memorial Boulder

DEDICATION OF LINDAHL-UDDEN MEMORIAL

M. M. LEIGHTON
Chief, Illinois State Geological Survey, Urbana

Address presented at the dedication of the Lindahl-Udden Memorial, Augustana College, May 5, 1950*

We treasure these golden moments, set aside at the close of the day's program of the Illinois State Academy of Science, to do honor to two great men of science, Josua Lindahl and Johan August Udden, who belong to the early days of Augustana College. These two names are indelibly written in the annals of this College and in the memories of a host of scientists throughout the nation.

Josua Lindahl

If Josua Lindahl were living now he would be called a zoologist by zoologists and a paleontologist by geologists. He had the breadth of interest of the natural scientist. He was the first to occupy the chair of Natural Science at Augustana College.

It takes little imagination to realize the problems that faced the college authorities of that day in choosing a man to trust with the introduction and the development of a curriculum in science. From the beginning this institution has emphasized the acquisition of both wisdom and knowledge, a rounded value which calls for exceptional administration and mature teaching.

This was in 1878 and Lindahl was 34 years old. The Swedish government had sent him to the Centennial Exposition in Philadelphia in 1876 as Assistant to the Commissioner-General in charge of the Swedish exhibit. For a while after the exposition closed Lindahl was placed in charge of Philadelphia's new Permanent International Exhibition. Actually his department was the only one that was ever completed; the plan soon failed for lack of funds. Augustana College and Theological Seminary saw in him an enthusiastic scientist and a devoted man, and, it is said, he became the first professor at the college who was not a minister. He brought with him his bride, Sophie Pahlman, whom he had returned to Sweden to marry in 1877. Four children were born to them while they lived at Augustana; the oldest died at an early age.

A. R. Cervin, who loved botany, had already created interest in the subject at Augustana. He taught botany for a year or two in addition to his other technical subjects. It is believed that Lindahl's decade of service at Augustana placed scientific instruction on a firm basis.

Lindahl was the son of a clergyman of the Lutheran State Church. His father died when Josua was 10 years old, and he was sent to live with relatives in Karlshamn.

* The writer acknowledges the helpful services of Professor F. M. Fryxell of Augustana College and Miss Ruth Kerr of the State Museum for making available much basic material for preparing this address. References consulted include History of the Swedes of Illinois, History of Rock Island County, Swedes in America, Who Was Who in America, History of Illinois State Museum of Natural History, publications of Augustana College and publications of the Illinois Geological Survey, American Association of Petroleum Geologists, and Geological Society of America.

While a student in Karlshamn, preparing for the university, he assisted a professor in compiling the flora of the Province of Blekinge, and also collected a large herbarium and made the beginning of a good collection of Swedish land and fresh water shells which he later gave to the Augustana College Museum.

Throughout his stay at the University of Lund, he partly supported himself by private tutorship in the Von Essen family. He received further assistance by being once awarded the Thonander Stipend, voted once a year by the student body to the most worthy of their members. He also worked in the Museum of the University of Lund where he contacted Gwynn-Jeffreys, the British conchologist, who later invited him to use his pleasure yacht in order to make zoological dredgings off the west coast of Ireland. This was followed by an expedition under the auspices of the Royal Society of London to carry out the first deep-sea explorations in the Atlantic, and later in the Mediterranean.

The following year, 1871, he was zoologist of an expedition sent by the Swedish Academy of Science to make explorations in Greenland and to bring back massive blocks of meteoric iron which had been discovered the previous year. He also took part in dredging expeditions the two following summers along the coast of Sweden to study the prevalence and distribution of invertebrates which served as food for fish.

After Lindahl received his doctorate he taught zoology at the University of Lund until he was sent to Philadelphia. The background shows ample reasons why he was brought to Augustana. Lindahl remained at Augustana as Head of the Department of Natural Science for ten years, where he built up a strong sentiment for the study of science, and reflected his fame upon the department. The New Main Building for the teaching of science was completed in 1888 before he left Augustana.

After the death of Professor A. H. Worthen in May 1888, who had been State Geologist of Illinois since 1858, Lindahl accepted the commission as Curator of the State Historical Library and Natural History Museum at the State Capitol in Springfield. The State Museum had been established in 1877 and Worthen was made Curator. He had retained the title of State Geologist in spite of the fact that appropriations for the Geological Survey had ceased in 1872 except for publications of the work already done. The Curator was required by law to perform the duties of State Geologist. Upon assuming office Lindahl, acting as State Geologist, prepared Worthen's last report for publication (Volume VIII of the Geological Survey of Illinois), and added a revised index and a reproduction of the geological map, then out of print, on a small scale. Lindahl deeply appreciated Worthen's magnificent work and in his letter of transmittal to Governor Joseph W. Fifer he outlined a sound program for future Geological Survey work. This, however, was not acted upon.

There was much interest in the forthcoming Columbian Exposition in Chicago and Lindahl prepared a geologic exhibit for the Illinois State Building and had charge of it until July.

Lindahl devoted his entire energies to the work of the Museum. He had never regarded his office as political, but after the election of a new State administration his resig-

nation was called for and his term of office ended in July 1893, after five years of tenure. After this unfortunate incident, Lindahl taught for two years in Chicago and then became Director of the Cincinnati Society of Natural History beginning in December 1895. As Director, he edited the Journal of the Cincinnati Society of Natural History until 1906 when at the age of 62, he moved to Chicago where he lived until his death in 1912.

The special esteem given Lindahl was shown by the high honors he received from the Government of Sweden; he was made Officier d' Academie in 1875 and was decorated by King Oscar II with the Royal Order of Vasa in 1877. As a biologist he showed unusual breadth of interest, carrying membership in both the American Society of Vertebrate Paleontologists and the American Society of Invertebrate Paleontologists.

Johan August Udden

Johan August Udden succeeded Lindahl at Augustana College in 1888. He was an Augustana graduate of the class of 1881, a student of Lindahl and a member of Professor Cervin's first class in botany.

Like Lindahl, Udden was born in Sweden but was Lindahl's junior by 15 years. He came to Minnesota with his parents in 1861 at the age of 2 years.

From his graduation at Augustana, at the age of 23, he went to Bethany College, Kansas, as one of its founders and one of its first teachers. He taught many subjects there and also edited the local paper; indefatigable work characterized his whole career. In 1882, early in his teaching assignment at Bethany, he married Johanna Kristina Davis, who was his helpmate throughout his life. One daughter and three sons were born to them. The daughter died while still very young and two sons died in manhood, Jon, the geologist, and Anton, the meteorologist and physicist. His son Svante became a businessman.

Udden filled the chair of Natural History and Geology at Augustana from 1888 to 1911, a period of 23 years. He taught various courses in botany, zoology, astronomy, physiology, meteorology, and geology, and at times helped out in other fields. He founded a series of monographs, Augustana Library publications, contributing five of the volumes. He published a total of 46 papers during his professorship besides carrying a teaching burden that today would be considered unfeasible for a research man. This is all the more noteworthy in view of his limited professional scientific training. which in addition to what he received at Augustana included a part of the year of 1886 at the University of Minnesota. It was necessary for him to rely on his own powers of observation and reasoning and to devise his own methods of approach and technique. Throughout his life he constantly turned up something new.

At Augustana he wrote fundamental papers on the deposition of dust from the atmosphere, the mechanical composition of clastic sediments, and the sedimentary cycles of the Pennsylvanian period. He brought out, too, that much could be learned about the subsurface rocks by the minute examination of well cuttings, and he was a pioneer in that field.

After he had written in the 17th annual report of the United States Geological Survey, "An Account of the Paleozoic Rocks Explored by

Deep Borings at Rock Island, Illinois and Vicinity,'' had prepared a geologic section of northern Illinois in the report of the World's Fair Commissioners, and had become know for his exact and original work, he was selected by Director H. Foster Bain as one of the first geologists on the new scientific staff of the new Illinois Geological Survey in 1905. Previously he had served as special assistant on the Iowa Geological Survey from 1897 to 1903, and gave temporary service to the University of Texas in 1903-04. His reports for the Illinois Survey are held in high regard to this day.

Udden developed a love for Texas during his field work in west Texas in 1903, and was persuaded to become a geologist on the staff of the Bureau of Economic Geology and Technology at the University of Texas in 1911, of which he became director in 1915. His contributions to the geology of Texas became as outstanding as they had been to Illinois and Iowa. Udden had already developed the anticlinal theory of origin of quicksilver deposits in 1904 in his study of the Terlingua deposits, and he had already written a masterpiece in his ''A Sketch of the Geology of the Chisos Country, Brewster County, Texas,'' which he finished in 1905. Udden established the first subsurface laboratory in Texas and various oil companies followed his action. By studies in his own laboratory of drill cuttings from the great Permian basin of the Southwest, he discovered the occurrence of potash deposits which convinced him that Texas and New Mexico probably contained workable reserves, a conclusion since confirmed by the development of a large industry in New Mexico.

It is well known that he was the first to advise the regents of the University of Texas of the probable occurrence of oil and gas on the lands of the University of Texas in Reagan County. This led to the discovery of the Big Lake oil field, the forerunner of other west Texas and New Mexico fields. Revenue from its oil lands have amounted to many millions of dollars for the University.

In the teens of this century, Udden became convinced that geophysical research would be useful in leading to the discovery of new oil and gas fields. However, he delayed his publication until 1920. Since then these methods have proved to be of inestimable value in America and elsewhere. His ''Review of the Geology of Texas'' in 1916 with the first large scale geologic map of the state became geology's ''best seller,'' requiring several editions that totaled more than 50,000 copies. It appeared in time to anticipate the boom in Texas oil during the First World War.

Udden's policies as Director of the Bureau of Economic Geology were born of his own personal integrity. The Bureau never engaged in propaganda for its own benefit nor has it lent itself to be the servant of any special interest. Along with his intellectual honesty went the modesty of a scientist and human kindliness. He gave of his mind and heart to enrich and better the world, a true criterion of the spirit that entered into the founding of his Bethany College.

Udden was one of the first to be made an honorary member of the American Association of Petroleum Geologists and of the Society of Economic Paleontologists and Mineralogists. He was a Fellow of the

Geological Society and of many scientific academies for many years. He earned the degree of Master of Arts from Augustana College in 1889 and was honored by his Alma Mater with the honorary degree of Doctor of Philosophy in 1900 and Doctor of Laws in 1929. Bethany College conferred upon him the degree of Doctor of Science in 1921, and Texas Christian University repeated the honor in 1923. King Oscar II of Sweden knighted him with the Order of the North Star in 1911 when he left Augustana for his new field in Texas.

And now recognizing the rare good fortune of Augustana College in having chosen Lindahl to occupy the first chair of Natural Science and in having produced and accepted Udden as her own son and distinguished scientist, we invite with reverence Dr. Udden's grandson, Marshall Udden, to withdraw the veil from this boulder, on which is inscribed the two names, "Lindahl" and "Udden," which we trust will perpetuate for the long future our tribute to them and which will always bring honor to Augustana and inspire its students and faculty.

So when a great man dies,
For years beyond our ken,
The light he leaves behind him lies
Upon the paths of men.
—Henry Wadsworth Longfellow

THE BEGINNING OF THE ILLINOIS STATE ACADEMY OF SCIENCE*

WILLIAM M. BAILEY
Southern Illinois University, Carbondale

By the middle of the nineteenth century, interest in different fields of science was growing in Illinois, as in other states. Various scientific organizations were formed, some limited to certain sciences, others to local situations. In the former group may be mentioned the first Geological Survey of Illinois (7), which began in 1851, the Illinois State Agricultural Society (6), which was organized at Springfield in 1853, the State Natural History Society of Illinois (2), which was organized at Bloomington in 1858, and the present Illinois State Geological Survey (1), organized in 1905. In the latter group the Chicago Academy of Sciences (3), organized in 1857, was preeminent, and other local scientific organizations may be noted. The Ottawa Academy of Natural Sciences (10) was founded in 1866. The Peoria Scientific Association (4) was organized in 1875. From a clipping from the Peoria *Journal-Transcript* of May 24, 1936, the following statement was taken: "As early as 1839 the Peoria Scientific and Historical Society was in existence." The Peoria Academy of Science of the present time was organized in 1930. The Academy of Science of Southern Illinois (5) was organized at Carbondale December 2, 1876.

As the years passed it came to be recognized as highly desirable that there should be a unification of the scientific interests of the state, and that an organization of those engaged in scientific work throughout the state should be formed. Accordingly, an invitation was extended to all persons engaged in the teaching of the sciences in the universities, colleges, and high schools, and those employed in other lines of scientific work, to meet at Springfield December 7, 1907 (8). More than 100 persons responded, among them a good representation of the leaders in the sciences in the universities.

The meeting was held in the Senate Chamber of the Capitol. The meeting was called to order by A. R. Crook, Director of the State Museum, at 10:00 A.M. U. S. Grant, of Northwestern University, was elected temporary chairman. Secretary of State James A. Rose, on behalf of the Governor of the State, welcomed the group to the State Capitol. T. C. Chamberlin, of the University of Chicago, gave the opening address. Professor Chamberlin introduced his address by extending the felicitations of the Chicago Academy of Sciences, and sketching some of the salient features of its history, covering a period of a little more than fifty years, as a means of suggesting some of the problems that the new academy

* This history of the first few years of the Illinois Academy of Science has been written because of the great scarcity of copies of Volume I and other early volumes of the Transactions of the Illinois State Academy of Science, in order that the membership of the Academy may know something about how the Academy was organized and began its work. The first two annual meetings are included in this sketch. The Committee will appreciate receiving any additional information or comments concerning the early history of the Academy.

would have to face. He then gave an address on the subject "The Advantages of a State Academy of Science." Professor S. A. Forbes, of the University of Illinois, then gave an address on the subject, "History of the Former State Natural History Societies of Illinois."

On motion of S. W. Williston, of the University of Chicago, A. R. Crook was elected temporary secretary. It was voted that the Chair appoint a committee of three on organization. This committee was authorized to add six others to its number. These nine were directed to draw up a constitution and nominate officers. The Chair appointed S. W. Williston, of the University of Chicago, W. A. Noyes, of the University of Illinois, and C. B. Atwell, of Northwestern University. This committee added T. C. Chamberlin, of the University of Chicago; S. A. Forbes, of the University of Illinois; A. R. Crook, of the State Museum; F. L. Charles, of the Northern Illinois State Normal; H. V. Neal, of Knox College; and B. B. James, of James Millikin University. While the committee was at work, there was a general discussion of the plans and aims of the organization. The meeting then adjourned until 2 P.M.

The afternoon session was called to order at 2:15 P.M. by the president pro tempore. The draft of the proposed constitution was presented by S. W. Williston, Chairman of the Committee. It was read by the Secretary of the Committee, F. L. Charles, and was then considered section by section. After revision and discussion the constitution and by-laws were adopted. It was voted that the first annual dues should apply for the year 1908. Chairman S. W. Williston then presented the report of the Committee on nominations. It was voted that the Secretary cast the ballot for the following nominations, and they were declared elected:

President, T. C. Chamberlin, of the University of Chicago.

Vice-President, Henry Crew, of Northwestern University.

Secretary, A. R. Crook, Director of the State Museum.

Treasurer, J. C. Hessler, of James Millikin University.

Third Member of the Publications Committee, H. F. Bain of the State Geological Survey.

Committee on Membership: S. A. Forbes, of the University of Illinois, chairman; T. W. Galloway of James Millikin University; J. P. Magnusson, of Augustana College; C. H. Smith, of the Hyde Park High School; B. B. James, of James Millikin University.

The Membership Committee was authorized to accept as charter members those persons who had previously expressed their desire to be enrolled as such, but were unable to be present at the meeting. The committee acted upon the names submitted. The president-elect, T. C. Chamberlin, was introduced by President pro tempore Grant. B. B. James, of James Millikin University, was appointed treasurer pro tempore in the absence of the Treasurer, J. C. Hessler.

A symposium upon "The Outlook for Young Men in the Various Sciences" was participated in by W. J. McGee, who spoke on "Anthropology," John G. Coulter, of the Illinois State Normal University, on "Opportunities in Botany," W. A. Noyes, of the University of Illinois, on "Openings for Chemists," H. Foster Bain, of the Illinois State Geological Survey, on the "Outlook for Young Men in Geology," Henry

Crew, of Northwestern University, on the "Outlook for Young Men in Physics," and H. V. Neal, of Knox College, on the "Outlook for Young Men in Zoology." Upon motion of W. E. Loomis, of Springfield, it was voted that 500 copies of the proceedings of the Organization Meeting be printed, and that one copy be furnished to each member of the society.

The meeting then adjourned until 8 P.M. In the evening session Dr. W. J. McGee delivered his lecture on the subject "Greater Steps in Human Progress," to an audience of about 600.

The addresses given at the organization meeting were published or reviewed in the first part of Volume I of the Transactions of the Illinois State Academy of Science.

CONSTITUTION AND BY-LAWS OF THE ILLINOIS STATE ACADEMY OF SCIENCE

Adopted at the Organization Meeting at Springfield, December 7, 1907

Constitution

ARTICLE I. NAME

This Society shall be known as the Illinois Academy of Science.

ARTICLE II. OBJECTS

The objects of the Academy shall be the promotion of scientific research, the diffusion of scientific knowledge and scientific spirit, and the unification of the scientific interests of the State.

ARTICLE III. MEMBERS

The membership of the Academy shall consist of Active Members, Non-resident Members, Corresponding Members, Life Members, and Honorary Members.

Active Members shall be persons who are interested in scientific work and are residents of the State of Illinois. Each active member shall pay an intiation fee of one dollar and an annual assessment of one dollar.

Non-resident Members shall be persons who have been members of the Academy but have removed from the State. Their duties and privileges shall be the same as those of active members except that they may not hold office.

Corresponding Members shall be such persons actively engaged in scientific research as shall be chosen by the Academy, their duties and privileges to be the same as those of active members, except that they may not hold office and shall be free from all dues.

Life Members shall be active or non-resident members who have paid fees to the amount of twenty dollars. They shall be free from further annual dues.

Honorary Members shall be persons who have rendered distinguished service to science and who are not residents of the State of Illinois. The number shall not exceed twenty at one time. They shall be free from all dues.

For election to any class of membership the candidate's name must be proposed by two members, be approved by a majority of the committee on membership, and receive the assent of three-fourths of the members voting.

All workers in science present at the organization meeting who sign the constitution, upon payment of the initiation fee and their annual dues for 1908 become charter members.

ARTICLE IV. OFFICERS

The Officers of the Academy shall consist of a President, a Vice-President, a Chairman of each section that may be organized, a Secretary, and a Treasurer. These officers shall be chosen by ballot on recommendation of a nominating committee, at an annual meeting, and shall hold office for one year or until their successors qualify.

They shall perform the duties usually pertaining to their respective offices.

It shall be one of the duties of the president to prepare an address which shall be delivered before the Academy at the annual meeting at which his term of office expires.

The secretary shall have charge of all the books, collections, and material property belonging to the Academy.

ARTICLE V. COUNCIL

The Council shall consist of the President, Vice-President, Chairman of each section, Secretary, Treasurer, and the president for the preceding year. To the Council shall be entrusted the management of the affairs of the Academy during the intervals between regular meetings.

ARTICLE VI. STANDING COMMITTEES

The Standing Committees of the Academy shall be a Committee on Publication and a Committee on Membership.

The Committee on Publication shall consist of the President, the Secretary, and a third member chosen annually by the Academy.

The Committee on Membership shall consist of five members chosen annually by the Academy.

ARTICLE VII. MEETINGS

The regular meetings of the Academy shall be held at such time and place as the Council may designate. Special meetings may be called by the Council and shall be called upon written request of twenty members.

ARTICLE VIII. PUBLICATION

The regular publications of the Academy shall include the transactions of the Academy and such papers as are deemed suitable by the Committee on Publication.

All members shall receive gratis the current issues of the Academy.

ARTICLE IX. AFFILIATION

The Academy may enter into such relations of affiliation with other organizations of appropriate character as may be recommended by the Council and be ordered by a three-fourths vote of the members present at any regular meeting.

ARTICLE X. AMENDMENTS

This constitution may be amended by a three-fourths vote of the members present at an annual meeting, provided that notice of the desired change has been sent by the Secretary to all members at least twenty days before such meeting.

BY-LAWS

I. The following shall be the regular order of business.

1. Call to order.
2. Reports of officers.
3. Reports of standing committees.
4. Election of members.
5. Reports of special committees.
6. Appointment of special committees.
7. Unfinished business.
8. New business.
9. Election of officers.
10. Program.
11. Adjournment.

II. No meeting of the Academy shall be held without thirty days' previous notice being sent by the Secretary to all members.

III. Fifteen members shall constitute a quorum of the Academy. A majority of the Council shall constitute a quorum of the Council.

IV. No bill against the Academy shall be paid without an order signed by the President and Secretary.

V. Members who shall allow their dues to remain unpaid for three years, having been annually notified of their arrearage by the Treasurer, shall have their names stricken from the roll.

VI. The Secretary shall have charge of the distribution, sale, and exchange of the published Transactions of the Academy, under such restrictions as may be imposed by the Council.

VII. The presiding officer shall at each annual meeting appoint a committee of three who shall examine and report in writing upon the account of the Treasurer.

VIII. No paper shall be entitled to a place on the program unless the manuscript or an abstract of the same shall have been previously delivered to the Secretary.

IX. These by-laws may be suspended by a three-fourths vote of the members present at any regular meeting.

The first regular annual meeting of the Illinois State Academy of Science was held in the James Millikin University, at Decatur, February 22, 1908 (8).

The meeting was called to order by the President of the Academy, Dr. T. C. Chamberlin, of the University of Chicago, at 10 A.M. There were 96 persons present. The Treasurer of the Academy, Dr. J. C. Hessler, of James Millikin University, made an announcement concerning the payment of dues, and also one concerning the plans for the meeting. Prof. S. A. Forbes, of the University of Illinois, Chairman of the Committee on Membership, reported a list of names of persons properly nominated and recommended for membership. These persons were voted into the organization.

The following papers were read in this session:

"Biotic Zones and Districts of Illinois"—Charles A. Hart (Ento-

mology), of the Illinois State Laboratory of Natural History, University of Illinois.

"A Case of Phosphorescence as a Mating Adaptation"—T. W. Galloway (Zoology), of James Millikin University.

"Some Problems Connected With the Coals of Illinois"—S. W. Parr (Chemistry), of the University of Illinois.

"The Desirability of a Systematic Ecological Survey from the Standpoint of Plant and Animal Associations"—H. C. Cowles (Botany), of the University of Chicago.

"A State Ecological Survey"—E. N. Transeau (Botany), of the Eastern State Normal School, at Charleston.

"A Virgin Prairie in Illinois"—H. A. Gleason (Botany) of the University of Illinois.

"Occurrence of Oil and Gas in Eastern Illinois"—H. Foster Bain, of Illinois State Geological Survey.

"Illinois Trees"—T. J. Burrill (Botany), of the University of Illinois.

"Plant Pathology in Relation to Other Sciences"—Ernest S. Reynolds (Botany), of the University of Illinois.

President Chamberlin spoke on the desirability of affiliating with other scientific societies in the State. He gave an account of the discussion at the meeting of the Council, held in Chicago, December 30. He invited those interested in considering plans to meet at 1:45 P.M., before the opening of the afternoon session.

Professor Forbes stated that as a result of the work of many years, a great mass of ecological material had been collected by the Natural History Survey, named and labeled, and that this material was at the disposal of students. He spoke of his gratification because of the increasing enthusiasm for the work.

A. R. Crook, Director of the State Museum, expressed the hope that the Academy would aid the State Museum in securing materials to illustrate the mineral resources of every section of the State, and the relation of animals and plants to each other and to their environment in various parts of the State. C. C. Adams, of the University of Chicago, suggested that a definite work be taken up, so that a report could be made on some locality.

The meeting was then adjourned until 2:00 P.M.

In the afternoon session, which began at 2:25 P.M., the following papers were presented:

"Relation of the State Academy to the Natural History Survey of the Chicago Academy of Sciences"—Frank C. Baker, of the Chicago Academy of Sciences.

"Farm Water Supplies"—Edward Bartow (Chemistry), of the University of Illinois.

President Chamberlin made an announcement concerning the publication of the Transactions, requesting all who were taking part in the program to send copies or abstracts of their papers to the secretary for publication. He expressed the hope that means for publication would be provided by the State Legislature as was customary in other states.

By the passage of a motion offered by H. F. Bain, of the State Geological Survey, the President of the Academy was instructed to appoint a committee of five on the collection of drill records.

A motion, made by S. A. Forbes, was passed authorizing scientific organizations that enter into relations of affiliation with the Academy each to appoint one of its members

to be a member of the Council of the Academy, who should have the right to vote on matters specifically related to the terms of affiliation, but not on other matters. On motion of H. F. Bain, it was voted to invite appropriate organizations each to appoint some member of the organization to represent it on the Academy Council while an ecological survey of the State was being made.

A symposium on "The Atmosphere" was participated in by T. C. Chamberlin (Geology), of the University of Chicago; Albert P. Carman (Physics), of the University of Illinois: H. C. Cowles (Botany), of the University of Chicago; John M. Coulter (Botany), of the University of Chicago; Wm. A. Noyes (Chemistry), of the University of Illinois; Charles E. M. Fischer, of the College of Physicians and Surgeons of the University of Illinois; and H. Foster Bain, of the State Geological Survey.

The meeting was then adjourned.

At the evening session, beginning at eight o'clock, A. A. Michelson, of the University of Chicago, lectured on the subject, "Recent Advances in Spectroscopy."

Abstracts of the papers read at the first annual meeting of the Academy, and the address of Dr. A. A. Michelson in the evening were published in the Transactions of the Illinois State Academy of Science, Volume I, 1908.

The Council meeting of the Illinois Academy of Science was held in Chicago, in the Auditorium Annex, Friday, May 8, 1908, beginning at 2:30 P.M.

On motion of Professor Crew, of Northwestern University, the following committee upon the ecological survey of the State of Illinois was appointed: S. A. Forbes, of the University of Illinois, Chairman; F. C. Baker, of the Chicago Academy of Sciences; H. C. Cowles, of the University of Chicago; H. A. Gleason, of the University of Illinois; and T. L. Hankinson, of the Eastern Illinois State Normal.

The Council voted to publish the "Transactions" of the Academy, which should include the transactions of the organization meeting held December 7, 1907, at Springfield, and the first regular meeting held in Decatur, February 22, 1908, the Constitution of the Academy, and the list of members.

The Council decided to hold the next meeting of the Academy at Springfield, February 20, 1909. It was decided that the program of this meeting should consist of a business meeting and the reading of papers in the morning, a symposium on the scientific activities of the State, their history, methods, and purposes, in the afternoon, and an address by the retiring president in the evening.

The Council then adjourned.

The second annual meeting of the Illinois State Academy of Science was held in Springfield in the Old Supreme Court Room in the State House, February 20, 1909 (9).

The meeting of the Academy was called to order by Vice-President Henry Crew at 10:00 A.M. The minutes of the last meeting were read by Secretary Crook, and approved. The Treasurer, J. C. Hessler, presented his report. This was laid on the Chairman's table until an Auditing Committee could be appointed to examine it. Secretary Crook requested that the members send in their correct addresses, degrees, and the names of the subjects in which they are interested, in order that the records of the Academy might be as complete as possible.

Professor S. A. Forbes, Chairman of the Membership Committee, then presented the report of his committee. This was approved, and the Secretary was instructed to cast the ballot of the Academy for those nominated for membership.

Professor S. A. Forbes, Chairman of the Committee on Ecological Survey, made the following report on the progress of this work.

One of the first tasks of an ecological survey is the recognition and description of the plant and animal associations represented. This may be reached by the detailed study and mapping of limited districts chosen from various parts of the state and representative of much larger areas. The results of this detailed work will give by comparison a general idea of the structure of the associations throughout the state. It may be supplemented by a more general study of the entire state, showing the distribution of such association groups as forest and prairie, sand regions, cypress swamps, etc. Both lines of work lead to the production of an ecological map of the state, showing the distribution of all the associations represented. Survey work of this nature will give appreciable results in a comparatively short time, will indicate the general nature of the survey, will serve as a pattern to amateurs, will open a large field for the use of teachers, and will be a foundation for subsequent investigation. Work on other phases of ecology, such as the correlation of associations with environmental factors or their interrelations with each other, will necessarily accompany the cartographic work to some extent.

Members of the committee reported the following field work under way:

F. C. Baker, ecological study and mapping of limited area at Shermerville, with especial reference to Mollusca.

H. C. Cowles, mapping the plant associations of portions of the South Chicago area.

H. A. Gleason, a study of the vegetation of inland sand deposits.

T. L. Hankinson, the breeding habits of fish near Charleston, correlated with environmental conditions.

V. E. Shelford, ponds in the dune region at the head of Lake Michigan.

E. N. Transeau, plant associations in the vicinity of Charleston; studies of evaporation.

After a discussion of the need of state aid for the survey, it was formally recommended by the committee that,

instead of a separate organization, the Academy cooperate with the State Laboratory of Natural History in securing funds and in carrying out the work of the proposed ecological survey. The State Laboratory has been engaged in this work for years, and is now willing to aid in the survey and to bring together in a comprehensive plan the ecological results of the work of both institutions and individuals.

The committee especially wishes to bring into its membership all persons prepared and disposed to do active work on the ecology of any part of the state.

The report was approved; and the committee was continued for another year.

Chairman Crew then appointed the following committees:

Committee on Nominations—W. F. M. Goss, University of Illinois; F. L. Charles, University of Illinois; S. W. Parr, University of Illinois; T. W. Galloway, James Millikin University.

Committee to Audit the Treasurer's Report—F. R. Watson, University of Illinois; H. O. Barnes, High School, Springfield; R. O. Graham, Illinois Wesleyan University; T. W. Galloway.

The Secretary then stated that a committee to collect drill records was to have been appointed the preceding year. He suggested that this committee be appointed at this time, or a little later in the day. Mr. F. W. De Wolf, Acting Director of the State Geological Survey, suggested Professor J. A. Udden for appointment on this committee, stating that "a great deal of the work is now in his hands." Chairman Crew suggested that, because of the import-

ance of the Committee and the need of further consideration, the appointment of the Committee be postponed until later in the day. This suggestion was accepted.

After some discussion of the desirability of having sectional meetings, the following motion was passed: "That it is the sense of the Academy that we should not resolve our meetings into sectional meetings at this time."

After the conclusion of the business meeting Isabel S. Smith, of Illinois College, Jacksonville, presented a paper on the subject, "Illinois Trees."

In leading the discussion on this paper, Professor Forbes said:

I think the reason the pioneers settled along the streams was because of the shelter, and because most of the earliest settlers came from forest countries. We see, in reading the records of the first explorers, that there was a general prejudice against the prairies, as being bare and lonesome, and practically worthless for agriculture.

Dr. Crook said:

I might say that at the last session a law was passed by the State Legislature designating the 'native oak' as the symbolic tree of this State. If the lawmakers had consulted with some one like Miss Smith they might have found out that there are sixteen varieties of native oaks in this State—another illustration of the fact that our laws would often be better if they were framed by men who availed themselves of the knowledge of experts.

The following papers were then presented without discussion:

"Some Botanical Features of Illinois Sand Dunes"—H. A. Gleason (Botany), University of Illinois.

"Preliminary Report of Observations upon a Robin's Nest"—F. L. Charles (Zoology and Botany), University of Illinois.

"Cliff Flora of Jo Daviess County"—H. S. Pepoon (Zoology and Botany), Lakeview High School, Chicago. Read by title only.

"The Clay Seams of No. 5 Coal Bed in the Springfield Quadrangle"—T. E. Savage (Stratigraphic Geology), University of Illinois.

The meeting then adjourned until 2:00 P.M.

The Academy was called to order at 2:15 P.M. by Chairman Crew. S. A. Forbes, Chairman of the Membership Committee, made a report on additional names of persons proposed for membership in the Academy. The number of new members added at both the morning and afternoon sessions was 42.

The following papers were then presented:

"Hardness of Illinois Municipal Water Supplies"—Edward Bartow (Chemistry), University of Illinois.

"Electrolytic Separation of Metals by Graded Electromotive Forces"—Albert Carver (Physics), Springfield High School.

After the presentation of these papers, Chairman Crew called for reports of committees.

F. R. Watson, Chairman of the Auditing Committee, stated that the Treasurer's report was found to be correct. The Treasurer's report as presented at the morning session was then adopted unanimously.

On making the report of the Committee on Nominations, W. F. M. Goss, Chairman of the Committee, expressed the appreciation of the committee for the efficient work of Vice-President Henry Crew in serving as Chairman of the meeting of the Academy. He stated that Dr. Crew had positively declined to accept the nomination for President of the Academy. He then presented the names of the following nominees for the ensuing year:

For President of the Academy—S. A. Forbes, University of Illinois.

For Vice-President — John M. Coulter, University of Chicago.

For Secretary—A. R. Crook, Director of the State Museum, Springfield.

For Treasurer—J. C. Hessler, James Millikin University.

For the third member of the Publications Committee—H. F. Bain, State Geological Survey.

For Membership Committee — T. W. Galloway, James Millikin University, Chairman; F. L. Charles, University of Illinois; U. S. Grant, Northwestern University; T. L. Hankinson, Eastern Illinois State Normal; S. W. Williston, University of Chicago.

The report of the Committee on Nominations was adopted unanimously, and the ballot of the Academy was cast for the nominees by the Chair.

Chairman Crew then announced the following Committee on Deep Drillings: J. A. Udden, of Augustana College; U. S. Grant, of Northwestern University; and F. W. De Wolf, of the State Geological Survey.

In a symposium on "The Scientific Activities of the State, Their History, Method and Purpose," the following papers were presented:

"State Laboratory of Natural History and the State Entomologist's Office"—S. A. Forbes.

"State Water Survey"—Edward Bartow.

"State Highway Commission"—A. N. Johnson.

"State Geological Survey"—F. W. De Wolf.

"State Museum of Natural History"—A. R. Crook.

After some discussion, a motion was passed unanimously to appoint a committee to secure funds from the State Legislature for the publication of the Transactions of the Academy.

A motion was passed authorizing the appointment of a committee to make a recommendation to be presented to the State Legislature, urging the erection at Springfield of a building to contain the State Museum. Chairman Crew appointed the following committee to take charge of whatever legislative recommendations the Academy thought wise: S. A. Forbes, John M. Coulter, A. R. Crook, and J. C. Hessler. Forbes, Crook, and Hessler of this committee met March 1, 1909, and adopted a report and resolution strongly urging that the State Legislature should take steps to provide an adequate building for the State Museum, either alone or with other appropriate State departments.

The afternoon session of the Academy adjourned until 6:00 P.M., when a banquet was given to the members of the Academy by the Chamber of Commerce of Springfield, in the Y. M. C. A. Building. At the banquet the following addresses were given by members of the Academy:

"Botany and Commerce"—Wm. Trelease (Botany), Missouri Botanical Garden, St. Louis.

"Science and Transportation"—W. F. M. Goss (Steam Engineering), University of Illinois.

"Illinois With or Without Science"—R. O. Graham (Chemistry), Illinois Wesleyan University, Bloomington.

"The Relation of Sciences to Each Other"—Henry Crew (Physics), Northwestern University.

All of the papers presented at this meeting of the Academy and the addresses at the banquet were published in the Transactions of the Illinois

State Academy of Science, Volume II, 1909.

The Council meeting of the Academy was held in the Botany Building of the University of Chicago, November 1, 1909. Those present at the meeting were S. A. Forbes, John M. Coulter, A. R. Crook, and J. C. Hessler.

The following decisions were made concerning the next annual meeting of the Academy. The cordial invitation of the University of Illinois to hold the meeting at Urbana was accepted. It was decided that the meeting would begin at 2:00 P.M. on Friday, February 18, 1910, and close Saturday afternoon, February 19. The Council planned for the program to consist of a business meeting, presentation of papers, address by the retiring president, and a symposium on "The Relation of Pure and Applied Science (A) to the Progress of Knowledge and to Practical Affairs, and (B) to Secondary Education." The symposium was to be participated in by five speakers chosen by the Council to present the subject from the point of view of the biologist, the chemist, and the physicist.

Isabel S. Smith, of Illinois College, Jacksonville, was appointed third member of the Publication Committee to succeed Dr. H. Foster Bain, elected at the last meeting of the Academy, who had resigned because of his removal to California.

The meeting of the Council was then adjourned.

REFERENCES

1. Bain, H. Foster, The Initiation of the State Geological Survey. Illinois State Geological Survey Bulletin No. 60: 29-33, Urbana, 1931.
2. Forbes, S. A., History of the Former State Natural History Societies of Illinois. Transactions of the Illinois State Academy of Science I:18-30, 1908.
3. Higley, William Kerr, Historical Sketch of the Academy. Special Publication Number 1 of the Chicago Academy of Sciences, Chicago, 1902.
4. Hilderbrand, Elizabeth, Head, General Reference Section, Peoria Public Library, Private Letter, April 5, 1949.
5. History of Jackson County, Illinois, with Illustrations etc.: 66-67, Philadelphia, 1878.
6. Prairie Farmer, May, 1853: 190-192.
7. Rolfe, C. W., Investigations Previous to the Founding of the Present State Geological Survey. Illinois State Geological Survey Bulletin No. 60: 23-26, Urbana, 1931.
8. Transactions of the Illinois State Academy of Science, Volume I, 1908.
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10. Whitenack, Arthur E., Librarian, Reddick's Library, Ottawa, Illinois, Private Letter, March 18, 1949.

PROGRAM FOR THE 43rd ANNUAL MEETING
PAPERS PRESENTED

ARCHAEOLOGY AND ANTHROPOLOGY

C. C. BURFORD, *Chairman*
Urbana

1. More Data on Sites of the Peoria, Illinois, Region: Mrs. Ethel Schoenbeck, Peoria.
2. You Can Still Find More of Them: Dr. Dan Morse, Peoria.
3. The Illinois State Archaeological Society and Its Journal: Byron W. Knoblock, Quincy, President, Illinois State Archaeological Society.
4. Symposium, The Black Hawk War Area and Background: Irving W. Hurlbut, Davenport, Iowa, presiding.
   Speakers—John H. Hauberg, Rock Island; Irving W. Hurlbut, Davenport, Iowa; Russell Neuwerk, Moline; E. Lee Siemon, Rock Island.
5. Birdstones: Dr. T. Hugh Young, Nashville, Tenn.
6. Bannerstones: Ben Nussbaum, Fairbury, Illinois.
7. Pictures of Archaeology of Southern Illinois: Irwin Peithman, Southern Illinois University, Carbondale.

BOTANY

R. A. EVERS, *Chairman*
Illinois State Natural History Survey, Urbana

1. Albinism in Plants: Sister Mary Helen O'Hanlon, Rosary College, River Forest.
*2. The Ligneous Flora of Richland County, Illinois, by Robert Ridgway, an Unpublished Manuscript: George D. Fuller, Illinois State Museum and University of Chicago.
*3. The Carr and Daniels Collections of Fossil Plants from Mazon Creek: Wilson N. Stewart, University of Illinois, Urbana.
4. The Use of C^{14} in Plant Studies: Norbert J. Scully, Argonne National Laboratory, Chicago.
*5. Microscopic Anatomy of the Wood of Three Species of Junipers: Margaret Kaeiser, Southern Illinois University, Carbondale.
6. Absorption of Antibiotics by Natural Substrates: Paul Siminoff and David Gottlieb, University of Illinois, Urbana.
*7. Colchicine as a Mutagenic Agent for Streptomyces griseus: Erich Schuldt and David Gottlieb, University of Illinois, Urbana.
8. The Secondary Phloem of Heterangium americanum: John W. Hall, University of Illinois, Urbana.
9. Poisonous Plants of West-Central Illinois: R. Maurice Myers and T. Dee Seely. Senior author, Western Illinois State College, Macomb; junior author, High School, Patterson, Illinois.
*10. Plankton Counting Methods: Kenneth E. Damann, Eastern Illinois State College, Charleston.
*11. Utilization of Some Organic Acids by Streptomyces griseus for Streptomycin Production and Growth: C. V. Hubbard and H. H. Thornberry. Senior author.

* Published in this volume.

Rutgers University, New Brunswick, New Jersey; junior author, University of Illinois, Urbana.

12. Therapeutic Studies on Carnation Virus Diseases: Ralph W. Ames, University of Illinois, Urbana.

CHEMISTRY

F. O. GREEN, *Chairman*
Wheaton College, Wheaton

*1. Methoxyl Determination on Alkyl Esters of 2-Methoxybenzoic Acid: G. R. Yohe, Donald R. Hill, and Howard S. Clark, State Geological Survey, Urbana.
2. Preparation of Symmetrical N,N¹-Disubstituted Piperazines and Their Quaternary Ammonium Salts: D. R. Smith and R. L. Eifert, James Millikin University, Decatur.
3. Sodium in Our Present World: Elbert H. Hadley, Southern Illinois University, Carbondale.
4. Oxidation Potentials of Some Phenolic Compounds: F. P. Cassaretto and C. D. Lowry, Jr., Loyola University, Chicago.
5. The Use of Isotopes in Medicine: D. L. Tabern, Abbott Laboratories, Chicago.
*6. Kolbe Synthesis: G. W. Thiessen, Monmouth College, Monmouth.
7. Physical Methods in Paper Chromatography: Arthur A. Frost, Northwestern University, Evanston.
8. The Microbiological Assay of Vitamin B_{12} in Impure Solutions: Thomas J. Oliver, Abbott Laboratories, Chicago.
9. Coal Oxidation: Active Oxygen and the Russell Effect: G. R. Yohe, State Geological Survey, Urbana.

GEOGRAPHY

WILLIAM E. POWERS, *Chairman*
Northwestern University, Evanston

1. Europe's Climate Owes Much to Two Small Earth Features: W. O. Blanchard, University of Illinois, Urbana.
*2. Geographical Possibilities of Cork Production in the United States: Charles C. Yahr, Illinois State Normal University, Normal.
3. The Conservation of Coal for Metallurgical Coke: Walter H. Voskuil, Illinois State Geological Survey, Urbana.
4. Distribution of Beef Cattle in Florida: H. O. Lathrop, Illinois State Normal University, Normal.
*5. Water Resource Conservation in Illinois: H. E. Hudson, Illinois State Water Survey, Urbana.
*6. Slope Studies of Northern Illinois: Wesley Calef, University of Chicago, Chicago.
7. A Geographer's Concept of Conservation: Ernest E. Melvin, Northwestern University, Evanston.

GEOLOGY

H. B. WILLMAN, *Chairman*
Illinois State Geological Survey, Urbana

*1. Student Projects: an Experiment in Geologic Education: F. M. Fryxell, Augustana College, Rock Island.

* Published in this volume.

*2. Some Easily Constructed Models for Teaching Optical Mineralogy: Carleton A. Chapman, University of Illinois, Urbana.
*3. Atomic Models of the Silicates as an Essential Aid in the Teaching of Mineralogy: Donald M. Henderson, University of Illinois, Urbana.
*4. Glacial Lake Merrimac: J Harlen Bretz, University of Chicago, Chicago.
5. Evidence of the Extension of the Labradorean Ice Sheet into Eastern Iowa, Tazewell-Wisconsin Substage: Morris M. Leighton, Illinois State Geological Survey, and Paul R. Shaffer, University of Illinois, Urbana.
*6. Current Evaluation of the Cambrian-Keweenawan Problem: Gilbert O. Raasch, Illinois State Geological Survey, Urbana.
*7. The Mt. Simon Sandstone in Northern Illinois: J. S. Templeton, Illinois State Geological Survey, Urbana.
8. Geological Control of Exploratory Drilling: George M. Wilson, Illinois State Geological Survey, Urbana.
9. A Type of Boghead Coal in Illinois: R. M. Kosanke, Illinois State Geological Survey, Urbana.
*10. Petrology of the Lower Burlington Limestone in Western Illinois: Donald L. Graf, Illinois State Geological Survey, Urbana.
*11. Metamorphic Development of the Crawford Notch Quadrangle, New Hampshire: Donald M. Henderson, University of Illinois, Urbana.
*†12. Preglacial Gravels in Henry County, Illinois: Leland Horberg, University of Chicago, Chicago.

PHYSICS

CLARENCE R. SMITH, *Chairman*
Aurora College, Aurora

1. A Study of Inductive Circuits: Herbert A. Johnson, Augustana College, Rock Island.
2. The Special Theory of Relativity and Electromagnetic Induction: W. J. Hooper, Principia College, Elsah.
*3. Survey of City Noise: G. L. Bonvallet, Armour Research Foundation of Illinois Institute of Technology, Chicago.
4. Report of the New York, February, Annual Meeting of the American Association of Physics Teachers: Lester I. Bockstahler, Northwestern University, Evanston.
5. Projection of Polarization Phenomena: D. L. Eaton, Northern Illinois State Teachers College, DeKalb.
6. A New Instrument for Fluorimetry: Harris M. Sullivan, Central Scientific Company, Chicago.
*7. Spectral Characteristics of Flash Discharges: W. S. Huxford and H. N. Olsen, Northwestern University, Evanston.
*8. Photographic and Optical Techniques Useful in the Small-School Laboratory: Howard C. Roberts, University of Illinois, Urbana.
9. The Use of Radioactive Materials in the Undergraduate Laboratory: O. L. Railsback, Eastern Illinois State College, Charleston.
10. Measuring the Solar Constant and Studying Its Influence Upon the Earth's Climate: Albert M. Pezzuto, New Table Mountain Solar Observatory of the Smithsonian Institution, Wrightwood, California.
11. Magnetic Support for Obtaining High Centrifugal Fields: William H. Lucke, Southern Illinois University, Carbondale.

† This paper was presented at the meeting, but was not listed on the printed program.
* Published in this volume.

PSYCHOLOGY AND EDUCATION

R. WILL BURNETT, *Chairman*
Urbana

1. A Digest of Significant Papers Presented at the Annual Meeting of the National Association for Research in Science Teaching: N. E. Bingham, Northwestern University, Evanston.
2. Earth Science as a Prerequisite for the Teaching of Geography: Ben H. Wilson, Joliet Township High School and Junior College, Joliet.
3. Findings from a Common Learnings Course Involving Science: Mrs. Audrey Lindsey, University High School, University of Illinois, Urbana.
4. Experiences in Educating for Human Relations: Mrs. Ruth Franham Osborne, Hinsdale Township High School, Hinsdale.

*5. Validation by Means of the Sociogram of a Technique for Promoting Social Acceptability in Elementary School Children: Elva E. Kinney, Greenville College, Greenville.

6. Meeting Students' Needs: Charlotte L. Grant, Oak Park and River Forest High School.

*7. A Study of College Science Courses Designed for General Education: Robert A. Bullington, MacMurray College, Jacksonville.

8. Some Findings of a Study of Competencies Required in Successful Teaching of Science in the Schools of Illinois: T. A. Nelson, Lyons Township High School, LaGrange.
9. Experience in Program Modifications in Science: Nelson L. Lowry, Arlington Heights Township High School, Arlington Heights.
10. Findings from the "Holding Power" Study of the Illinois Secondary School Curriculum Project: Kenneth B. Henderson, University of Illinois, Urbana.
11. Educating Teachers Concerning Scientific Features of the Community: D. Elton Nelson, Hinsdale Township High School, Hinsdale.
12. The National Aviation Education Classroom Demonstration Project: Horace S. Gilbert, Civil Aeronautics Administration.
13. Science and Philosophy in General Education Programs: John H. Woodburn, Illinois Normal University, Normal.

SOCIAL SCIENCE

LEWIS MAVERICK, *Chairman*
Southern Illinois University, Carbondale

EMPHASIS ON SOCIOLOGY

*1. Sociological Problems in the Study of Industrial Relations: Donald E. Wray, University of Illinois, Urbana.

2. The Swedish Theatre of Chicago and Its Social Background: Henriette Naeseth, Augustana College, Rock Island.
3. What Is So Human About Ants and Termites? George K. Plochmann, Southern Illinois University, Carbondale.

*4. Recent Studies of the Relative Power of Nature and Nurture, Monozygotic Twins: Grace M. Jaffe, Barat College, Lake Forest.

5. The Social Studies for Future Teachers—A Functional Major: Fritiof O. Ander, Augustana College, Rock Island.

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* Published in this volume.

Emphasis on Government and Economics

1. The Administration of the Federal Airport Act: George B. Rea, Northwestern University, Evanston.
2. Supply and Demand for Pig Iron in the United States, 1904 to 1948: Lewis A. Maverick, Southern Illinois University, Carbondale.
3. Problems of Constitutional Revision in Illinois and Iowa: Stanley Erikson, Augustana College, Rock Island.
4. The Attitude of *The Chicago Tribune* Toward American Foreign Policy, 1939 to December 7, 1941: Marcus William Kulyan, Northwestern University, Evanston.
5. The Interdependence of the Social and Natural Sciences: G. Carl Wiegand, Loyola University, Chicago.
6. Beef Cattle Industry in Illinois, 1840-50: C. Clyde Jones, Northwestern University, Evanston.

*7. The Need for Corporate Research in the Social Sciences: J. K. Johnson, Southern Illinois University, Carbondale.

ZOOLOGY

CHARLES J. WIDEMAN, *Chairman*
Loyola University, Chicago

1. Etymological Problems in Herpetological Nomenclature: Albert G. Smith, Loyola University, Chicago.

*2. The Use of Horse Strongyle Larvae in Screening Compounds for Anthelmintic Activity: Norman D. Levine, University of Illinois, Urbana.

*3. Comparative Studies of Normal and Piebald Hamsters: Charles L. Foote and Florence M. Foote, Southern Illinois University, Carbondale.

4. Studies of Ciliates 1—The Encystment and State of Depression in Oxytrichidae: Dimitri Sokoloff, Mundelein College, Chicago.

*5. Field Notes on the Squash Bug, Anasa tristis (De Geer): W. V. Balduf, University of Illinois, Urbana.

*6. Ecological Notes on Silpha americana: E. J. Long, Quincy College, Quincy.

7. Our Food, Our Health, and Our Future: A. J. Carlson, University of Chicago, Chicago.

*8. An Investigation of the Occurrence of Enterobius vermicularis Ova in Dust from Homes and Public Buildings: Wayne W. Wantland, Mildred M. Carmichael, Clifford Storm, Mary Ho, Illinois Wesleyan University, Bloomington.

9. Cysticercus fasciolaris in the Wild Rat: Wayne W. Wantland, Kenneth E. Dye, Harold M. Kemple, Illinois Wesleyan University, Bloomington.

*10. A Study of the Incidence of Endamoeba gingivalis in a Central Illinois Community: Wayne W. Wantland, Hubert Engel, Seije Nakada, Illinois Wesleyan University, Bloomington.

11. Hunger Activity in Decerebrate Pigeon: William Sangster, University of Illinois (Navy Pier), Chicago.

12. Animal Succession in Temporary Ponds: John D. Parsons, Southern Illinois University, Carbondale.

*13. A New Method for Staining Cells with Cobalt and Bal: Theodore N. Tahmisian, Argonne National Laboratory, Chicago.

14. The Relationship of the Resting Potential of the Frog Eye to the Blood Sugar Level: Allyn E. Gilbert, University of Illinois, Urbana.

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* Published in this volume.

COLLEGIATE SECTION

HARRY J. FULLER, *Coordinator*
University of Illinois, Urbana

JANE MARTIN, *Chairman*
Monmouth College, Monmouth

1. An Alternative Separation of Copper and Cadmium Ions in Qualitative Inorganic Analysis: Ralph Medhurst, Monmouth College, Monmouth.
2. The Preparation and Purification of 3, 4-Dibromotoluene and Their Reaction with One Mole of Magnesium in the Grignard Reagent: John R. Dyer, Northwestern University, Evanston.
3. Studies on Acephaline Gregarines of Lumbricus Terrestris: Thomas C. Hartney, Loyola University, Chicago.
4. Automorphisms of a Cyclic Group: Virginia Tyler, Rockford College, Rockford.
5. Refractive Index versus Concentration Curves for Aluminum and Magnesium, Chloride and Bromide: James L. Baldwin, Eastern Illinois State College, Charleston.
6. Size and Pattern Variations in Plethodon cinereus from the Indiana Dunes: Edward Kos, Loyola University, Chicago.
7. Iodine Inhibition of Photochemical Reactions: Robert Martin, Northwestern University, Evanston.
8. The Preparation of Some Dialkyl Hydroquinones: John Cessna, Augustana College, Rock Island.
9. Antobiotics as Bacteriostatic Agents for the Cultivation of Cestodes in Vitro: Janet Boles, Monmouth College, Monmouth.
10. Location of Colorless Compounds on a Resolved Chromatogram: Peter Lykos, Northwestern University, Evanston.
*11. Study of Cicatrization in Plant Tissues: Dolores Bresingham, Mundelein College, Chicago.
12. Comparative Study of the Structure of the Nuclei of Some Volvocales: Marilyn Tucker, Mundelein College, Chicago.
13. Student Chemistry Research Program at Mundelein College: Joan Haninger, Mundelein College, Chicago.
14. Observations on the Effect of Magnesium Ion in the Blood of the Golden Hamster: Edward Shinn, Quincy College, Quincy.
15. Botanical Survey of the Campus of Western Illinois State College: Norman C. Place, Western Illinois State College, Macomb.
16. Separation of Crystalline Materials from Burdock and Plantain by Chromatography and Tests for Their Antibacterial Properties: Celine Paul and Lorraine Sporar, College of St. Francis, Joliet.

* Published in this volume.

BOTANY

THE LIGNEOUS FLORA OF RICHLAND COUNTY, ILL., BY ROBERT RIDGWAY

(AN UNPUBLISHED MANUSCRIPT)

GEORGE D. FULLER
Illinois State Museum and
The University of Chicago

When the home of the late Robert Ridgway, known as "Bird Haven," at Olney, Illinois, passed into the control of the Departments of Botany and Zoology of the University of Chicago and became a Nature Sanctuary, portions of the library of this distinguished scientist were stored in the Botany Building of the University of Chicago. Among other old manuscripts there was found one having the above title, and upon examination it was found to have been written by Mr. Ridgway during the last years of his life and for which he had not succeeded in finding a publisher.

In 1927, an abstract of this manuscript was presented at a meeting of the Illinois State Academy held at Joliet (Ridgway, R., The ligneous flora of Richland Co., Ill., Trans. Ill. State Acad. Sci. 20: 105-115, 1928) but the unpublished portions of the article contained so many details concerning the distribution of the different plant species in the county that it seemed important to preserve these details for the students of the flora of Illinois. There were three typewritten copies of the manuscript, in different stages of revision, and it seemed wise to deposit the three copies where they could be examined by botanists interested in the flora of Illinois. The institutions that were selected as the depositories of the manuscripts were the Illinois State Museum, Springfield; the Herbarium of the Department of Botany, the University of Illinois, Urbana; and the Chicago Natural History Museum, Chicago.

The best of the manuscripts, the only one with plates of photos of trees, has been accepted by the Director of the Illinois State Museum who has had it bound and placed in the library of the Museum. It contains 133 typewritten pages and 43 plates (photographs). It has many handwritten notes by the author and it contains copies of letters concerning Mr. Ridgway's correspondence in his efforts to get a publisher.

The other copies have been accepted by the curators of the herbaria of the University of Illinois and of the Chicago Natural History Museum and have been placed on file where they may be consulted by interested botanists.

REPORT ON THE CARR AND DANIELS COLLECTIONS OF FOSSIL PLANTS FROM MAZON CREEK

WILSON N. STEWART
University of Illinois, Urbana

The Natural History Museum of the University of Illinois[1] has had since 1920, two collections of fossil plants made up almost entirely of specimens from the now famous Mazon Creek area near Morris, Illinois. The collectors, L. E. Daniels and J. C. Carr, both resided in Morris, Illinois, when making their respective collections.

From the time these collections were procured by the University, the majority of the specimens remained in storage and for the most part inaccessible for study. At one time, part of the Daniels collection was investigated by A. C. Noé (1925) who published photographs of several specimens.

In order to make the material in the Carr and Daniels collections available for further study all specimens which were well enough preserved were identified and catalogued. The identification of specimens was done by comparing them with those previously figured and described by Zeiller (1888), White (1899), Noé (1925), Hirmer (1927), Bell (1938, 1944), and Janssen (1939, 1941). The generic and specific names were checked with those listed by Jongmans (1913-37).

The first extensive studies of the fossil flora of the Mazon Creek locality were by Lesquereux (1866, 1870). The results of his studies were later incorporated in a comprehensive account of the fossil plants of the American Carboniferous (1879, 1880). In a series of brief reports, White, while a member of the Illinois State Geological Survey, mentioned the occurrence of several genera of fossil plants from Mazon Creek. His observations on the fossil flora of the Pennsylvanian of Illinois resulted in the subdivision of this system into the Pottsville, Carbondale, and McLeansboro groups. Lesquereux's nomenclature (1866, 1870, 1879, 1880) was revised by Noé (1925), with more recent revisions of the fossil flora of Northern Illinois by Janssen (1939, 1941).

The Collections

The majority of the specimens are ironstone concretions with only a few compressions on shale and stem casts. Geographically, the Mazon Creek fossils are still to be found along the so-called Ox Bow of the Mazon River, 6 to 6¾ miles southeast of Morris extending from NE. ¼ sec. 24 to NE. ¼ sec. 25, T. 32 N., R. 7 E. Stratigraphically the concretions, when found in place, lie in the Francis Creek shale just above No. 2 coal of the Lower Carbondale group.

Because of the fragmentary nature of fossil plant remains the problems of their nomenclature and classification are more difficult than for living plants, where complete specimens are available. For this reason paleobotanists are primarily in-

[1] The author wishes to thank Professor D. F. Hoffmeister, Curator of the Natural History Museum, for making the Carr and Daniels collections available for study.

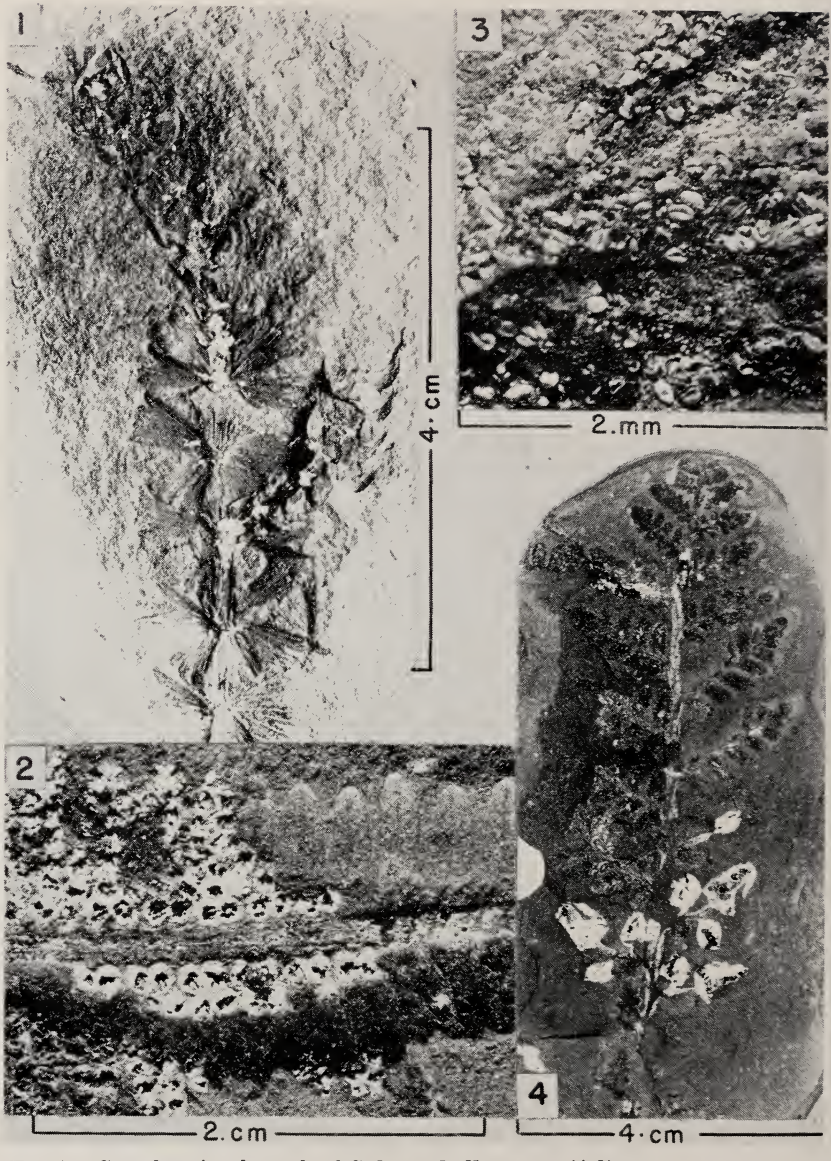

Fig. 1.—Cone-bearing branch of *Sphenophyllum cuneifolium.*

Fig. 2.—Pinna of *Pecopteris* (*Ptychocorpus*) *unita* showing fertile and sterile aspect of a pinnule.

Fig. 3.—Monolete spores of *Codonotheca caduca* in the matrix of a concretion.

Fig. 4.—Pinna of *Crossotheca sagittata* with fertile pinnules intercalary in position.

terested in those specimens which bear reproductive parts and thus indicate something of the natural affinities of the fossil plants. In the Carr and Daniels collections there are many fertile specimens of lycopsids, sphenopsids, and pteropsids. Figures 1-4 show some of the fructifications (see explanation of figures for more complete descriptions) which still contain spores within their sporangia (fig. 3). As is true of all fossil plant remains collected from the Mazon Creek locality, the majority is sterile leaf material of the genera Pecopteris and Neuropteris. Many of these sterile leaf fragments are large enough to show something of the high degree of polymorphism within a frond. A critical examination of this material, not undertaken here, may show that a number of species currently recognized as distinct can be grouped in only a few species.

Of the total number of specimens (4018) in the two collections, 758 belong to the Daniels collection and 3260 to the Carr collection. The combined collections have 103 different species belonging to 51 genera.

List of Genera and Species

(Number of specimens in Carr and Daniels Collections given in parenthesis)

Phylum—*Tracheophyta*
Subphylum—*Lycopsida*
Order—*Lepidodendrales*
Genera and species:
Bothrodendron sp? Lindley and Hutton (1)
Halonia sp? Lindley and Hutton (1)
Knorria sp? Sternberg (1)
Lepidodendron Sternberg (9)
L. aculeatum Sternberg (9)
L. dichotomum Sternberg (1)
L. lanceolatum Lesquereux (4)
L. obovatum Sternberg (25)
L. rigens Lesquereux (5)
L. rimosum Sternberg (2)
L. veltheimi Sternberg (3)
L. wortheni Lesquereux (3)
Lepidophloios sp? Sternberg (5)
L. acerosus Kidston (3)
L. luricinus Sternberg (2)
L. protuberans Lesquereux (1)
Lepidophyllum longifolium Brongniart (5)
Lepidostrobophyllum sp? Hirmer[2] (1)
L. brevifolium (Lesquereux) Hirmer (1)
L. intermedium (Lindley and Hutton) Hirmer (3)
L. lanceolatum (Lindley and Hutton) Hirmer (2)
L. lancifolium (Brongniart) (26)
L. majus (Brongniart) Hirmer (12)
L. ovatifolium (Lesquereux) Hirmer (45)
L. triangulare (Zeiller) Hirmer (7)
Lepidestrobus sp? Brongniart (3)
L. brevifolium Lesquereux (16)
L. brownii ? Schimper (1)
L. hastatus Lesquereux (3)
L. lancifolium Lesquereux (1)
L. oblongifolium Lesquereux (6)
L. triangularis Zeiller (2)
Sigillaria sp? Brongniart (2)
Stigmaria ficoides (Sternberg) Brongniart (10)
Syringodendron sp? Sternberg (4)
Order—*Lycopodiales*
Genus and species:
Lycopodites meeki Lesquereux (16)
Subphylum—*Sphenopsida*
Order—*Sphenophyllales*
Genera and species:
Sphenophyllum cuneifolium[3] Sternberg (1)
S. emarginatum (Brongniart) Koenig (18)
S. longifolium Germar (2)
S. majus (Bronn) Bronn (1)
Order—*Equisetales*
Genera and species:
Annularia sp? Sternberg (8)
A. radiata (Brongniart) Sternberg (127)
A. sphenophylloides (Zenker) Gutbier (32)
A. stellata (Schlotheim) Wood (88)
Asterophyllites sp? Brongniart (57)
A. equisetiformis Schlotheim (13)
A. longifolius (Sternberg) Brongniart (7)
Calamites sp? Schlotheim (16)
C ramosus Artis (2)
C. suckowi Brongniart (6)
Calamostachys sp? Schimper (8)
C. germanica Weiss (1)
C. magna Lesquereux (1)
C. solmsi (Weiss) Weiss (2)
Macrostachya sp? Schimper (2)

[2] Lepidostrobophyllum. Hirmer, M. 1927—Handbuch der Palaobotanik, Munchen und Berlin; 231. This genus, though a useful one, does not meet the requirements of valid publication according to the International Rules.

[3] This specimen bears two cones. (See fig. 1.)

M. infundibuliformis (Brongniart) Schimper (1)
Pinnularia Lindley and Hutton (4)
Subphylum—Pteropsida
Orders[4]—*Filicales* and *Cycadofilicales*
Genera and species:
Acitheca polymorpha (Brongniart) Schimper (4)
Alethopteris sp? Sternberg (2)
A. ambigua Lesquereux (10)
A. grandini (Brongniart) Goeppert (3)
A. lonchitica (Schlotheim) Unger (3)
A. serli (Brongniart) Goeppert (43)
Alloiopteris sp? Potonié (1)
Aphlebia sp? Presl (66)
Callipteridium sullivanti (Lesquereux) Weiss (17)
Carpolithes sp? Sternberg (4)
Caulopteris sp? Lindley and Hutton (16)
Codonotheca caduca Sellards (27)
Crossotheca sagittata (Lesquereux) Zeiller (63)
Cyclopteris sp? Brongniart (105)
Dactylotheca sp? *Zeiller* (2)
Diplothmema furcatum (Brongniart) Stur (5)
Eremopteris missouriensis Lesquereux (1)
Holcospermum sp? Nathorst (7)
Lagenospermum sp? Nathorst (1)
Linopteris muensteri (Eichwald) Potonié (4)
L. neuropteroides (Gutbier) Potonié (2)
Mariopteris sp? Zeiller (4)
M. decipiens ? Lesquereux (3)
M. mazoniana (Lesquereux) White (1)
M. muricata (Schlotheim) Zeiller (6)
M. muricata var. *nervosa* (Schlotheim) Zeiller (5)
M. sphenopteroides (Lesquereux) White (11)
Mixoneura sp? Weiss (2)
M. ovata (Hoffman) Weiss (10)
Neuropteris sp? Brongniart (23)
N. clarksoni Lesquereux (20)
N. crenulata ? Brongniart (2)
N. fimbriata Lesquereux (1)
N. flexuosa Sternberg (26)
N. gigantea Sternberg (8)
N. heterophylla Brongniart (14)
N. missouriensis Lesquereux (3)
N. rarinervis Bunbury (32)
N. scheuchzeri Hoffman (898)
N. tenuifolia (Schlotheim) Sternberg (26)
N. plicata Sternberg (9)
Odontopteris sp? Brongniart (17)
O. aequalis Lesquereux (8)
O. brardleyi ? Lesquereux (1)
O. schlotheimi Brongniart (2)
O. subcuneata Bunbury (5)
O. wortheni Lesquereux (8)
Oligocarpia sp? Geoppert (1)
Pachytesta sp? Brongniart (3)
Pecopteris sp? Brongniart (24)
P. (Asterotheca) abbreviata Brongniart (53)
P. (Asterotheca) arborescens (Brongniart) Sternberg (214)
P. (Asterotheca) candolleana Brongniart (3)
P. cisti Brongniart (7)
P. clintoni Lesquereux (7)
P. (Asterotheca) crenulata Brongniart (13)
P. (Asterotheca) hemitelioides Brongniart (4)
P. (Asterotheca) miltoni (Artis) Brongniart (651)
P. obliqua Brongniart (5)
P. (Asterotheca) oreopterida Schlotheim (26)
P. (Senftenbergia) pennaeformis (Brongniart) Sternberg (3)
P. (Dicksonites) pluckeneti (Schlotheim) Brongniart (59)
P. (Dactylotheca) plumosa (Artis) Brongniart (6)
P. pseudovestita White (22)
P. (Asterotheca) serpillifolia Lesquereux (33)
P. (Asterotheca) squamosa Lesquereux (19)
P. (Dactylotheca) sturi ? Sterzel (1)
P. (Ptychocarpus) unita Brongniart (545)
Schopfia sp? Janssen (1)
Sphenopteris sp? Brongniart (11)
S. artemisaefoloides Crépin (23)
S. (Oligocarpia) brongniarti (Zeiller) Stur (2)
S. (Renaultia) chaerophylloides (Brongniart) Presl (16)
S. (Renaultia) gracilis (Brongniart) Presl (6)
S. mixta Schimper (2)
S. obtusiloba Brongniart (6)
S. spiniformis Kidston (4)
S. subcrenulata ? Lesquereux (1)
Spiropteris sp? Schimper (13)
Sporangites accuminata ? Dawson (1)
Trigonocarpus sp? Brongniart (10)

Order—*Cordaitales*
Cordaianthus sp? Grand Éury (9)
Cordaicarpus sp? Geinitz (1)
Cordaites grandifolius Lesquereux (2)
Undetermined specimens (61)

[4] It has long been suspected that many of the homosporus fructifications borne on fern-like leaves and now assigned to the Filicales may, in reality, be the microsporangia of heterosporous members of the Cycadofilicales. Furthermore, there are many species with fern-like foliage, now assigned to artificial (form) genera, the reproductive structures of which are unknown. For these reasons it is impossible, in most cases, to assign a species with any degree of certainty to either the Filicales or Cycadofilicales. Thus, it is necessary to group these two orders.

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MICROSCOPIC ANATOMY OF THE WOOD OF THREE SPECIES OF JUNIPERS

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An attempt has been made to seek criteria for separating three American species of junipers on the basis of the microscopic structure of their wood. Peirce (4) has a key to genera of the Cupressaceae. Phillips (5) has described the microscopic wood anatomy of certain members of the genus *Juniperus* and has separated *J. virginiana* L. and *J. lucayana* Britt. from *J. procera* Hochst. (an East African form) on the basis of thin horizontal walls in the ray cells in the last named species (figs. 1, 5). *J. virginiana* L. and *J. lucayana* Britt. both were noted to have nodular thickenings on the vertical end walls of the ray cells (as shown for *J. monosperma* (Engelm.) Sarg., fig. 4), and in this respect are unlike any other species of conifer that he reported except *Libocedrus decurrens* Torr. *J. virginiana* L. is then separated from *L. decurrens* Torr. on the basis of the presence, in the former species, of intercellular spaces at the corners of the tracheids as observed in traverse section (fig. 7). He noted also that the cross-field pits are generally larger and are more regularly arranged in *J. virginiana* L. and *J. lucayana* Britt. than in *Libocedrus*.

Phillips also lists abundant wood parenchyma (relatively abundant for conifers), the presence of nodular thickenings on the transverse walls of parenchyma cells (fig. 6), and the cupressoid cross-field pits (fig. 4, 5, 6, 10) as characters serving to delimit the three junipers he reported from most other conifer woods. All three species reported by him have the typical "cedar-like" odor of pencils.

The writer has used *J. virginiana* L.; *J. Ashei* Buchh.; young (3-5 year old) twigs of hybrids of *J. virginiana* L. X *J. Ashei* Buchh.; *J. monosperma* (Engelm.) Sarg.; and *J. procera* Hochst. for comparative purposes. Wood samples were prepared in the usual manner (6) and sections were cut 20-30 microns thick. Macerated wood was prepared in Jeffrey's Solution.

Acknowledgment is made to the following people for assistance in providing materials: To Dr. B. Francis Kukachka, U. S. Forest Products Laboratory, Madison, Wisconsin, for *J. virginiana* L., from Linn, Florida; *J. Ashei* Buchh., from Austin, Texas; and *J. monosperma* (Engelm.) Sarg., from Arizona. Dr. Marion T. Hall, Henry Shaw School of Botany, Washington University, St. Louis, provided the hybrid *J. virginiana* L. X *J. Ashei* Buchh. which was collected on McVey Knob in Ozark County, Missouri, the most eastern known distribution of *J. Ashei* Buchh. Mr. Milton Scott of Miami, Florida, furnished the *J. procera* Hochst., from the U. S. Plant Introduction Garden. The *Metasequoia glyptostroboides* Hu and Cheng wood specimen was collected by Dr. Ralph W. Chaney from the Hupeh Province of China

and presented to Mr. O. A. Oakes of Wilmette, Illinois, from whom the writer procured a sample. It is used to illustrate the taxodioid type of cross-field pitting, as is also the *Podocarpus Comptonii* Buchh. that was collected by Dr. John T. Buchholz on Mt. Mou, New Caledonia (figs. 11, 12).

Local collections provided material for *Pinus sp.* and *Picea polita* (Sieb. and Zucc.) Carr. Figure 8 shows the large window-like pit found in certain of the pines, besides small pits of the pinoid type. Figure 9 shows the piceoid type of cross-field pit.

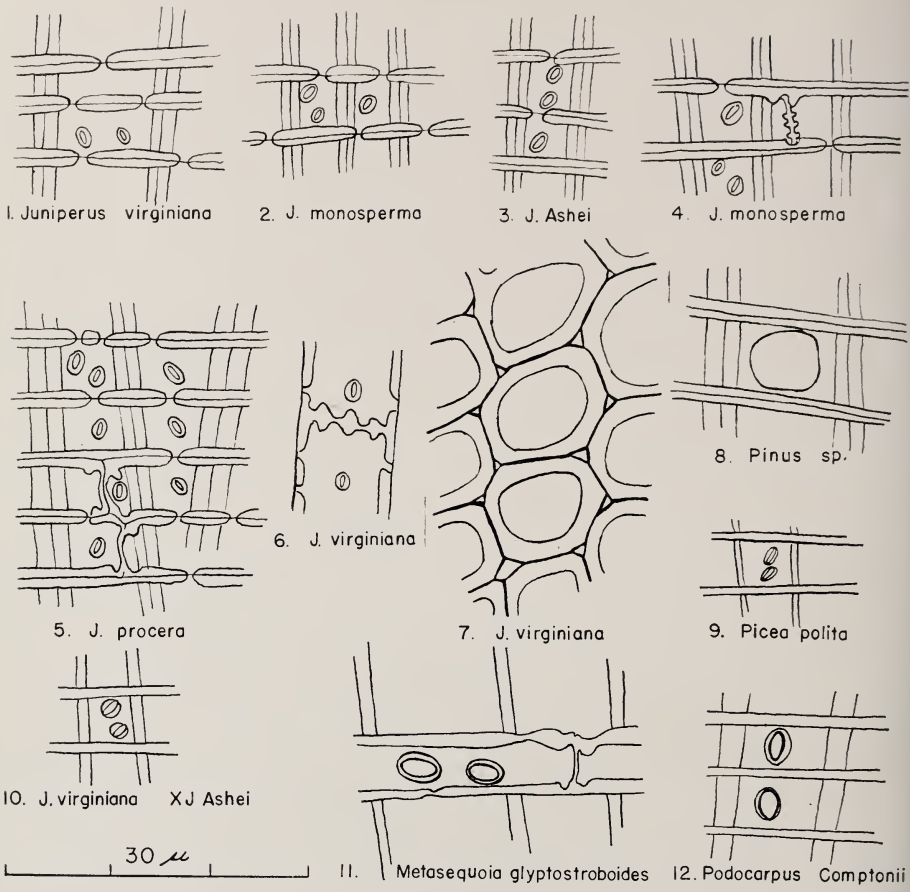
Table 1 summarizes the data for the species analyzed (1). The tracheid study from early wood disclosed the "very thin" wall character. The size of cross-field pit apertures, on a basis of ten random measurements, showed somewhat smaller sizes, on the average, in *J. Ashei* Buchh. and *J. monosperma* (Engelm.) Sarg. than in *J. virginiana* L. or *J. procera* Hochst. All were of the cupressoid type, although there have been reported occasional ones of the taxodioid type (5) (figs. 11, 12). Small tangential bordered pits were noted in all species though only rarely. Tangential pits are rare in early (spring) wood of conifers (3).

Tracheid length measurements from random counts of macerated wood were made of 100 tracheids for each species. The table gives means with their standard errors and standard deviations with their standard errors. Statistical treatment to measure the significance of the difference between means (2) i.e., the square root of the sum of the squares of the two standard errors of the means, was undertaken to compare the species with one another. This root is the standard error of the difference between the two means. In every case the difference between the means exceeded twice the root and is, therefore, to be regarded as significant. The hybrid was treated similarly and again showed significant difference from the parent types, as well as the other two species. However, the samples were of young wood only, the foliage of which was more like *J. Ashei* Buchh. than *J. virginiana* L. Further work is needed on mature wood. Tracheid length was greatest in *J. virginiana* L., with *J. Ashei* Buchh. and *J. monosperma* (Engelm.) Sarg. in descending order. There was less difference in tracheid length between the last two named species than when compared to *J. virginiana* L. Although *J. virginiana* L. and *J. Ashei* Buchh. hybridize easily, *J. virginiana* L. belongs to the polyspermous complex whereas *J. Ashei* Buchh. and *J. monosperma* (Engelm.) Sarg. both belong to the monospermous complex.

Intercellular spaces between tracheids were present in all species (fig. 7).

Except for *J. procera* Hochst. (fig. 5) the horizontal walls of the ray parenchyma are as thick, or nearly as thick, as the tracheid walls in early wood cross-field views (figs. 1, 2, 3, 4, 6). The end walls are nodular in all species except *J. procera* Hochst. (figs. 4, 5). Primary pit-fields occur in the horizontal walls of all species studied (figs. 1, 2, 3, 4, 5), and indentures are also consistently present (figs. 4, 5).

Xylem parenchyma is more abundant than five cells per square millimeter under magnification of X50 or more and is indicated as "Abundant for Conifers" for all species (5). It is present in all forms re-



FIGURES 1 TO 12

1. From radial section of wood showing cross-field pits of *Juniperus virginiana* L. of cupressoid type; primary pitfields in horizontal walls of ray parenchyma cells.
2. Same for *J. monosperma* (Engelm.) Sarg.
3. Same for *J. Ashei* Buchh.
4. Same for *J. monosperma* (Engelm.) Sarg.; also showing nodular walls of ray parenchyma cells and indentures.
5. From radial section of wood of *J. procera* Hochst. showing smooth end walls of ray parenchyma cells and indentures.
6. From tangential view of wood parenchyma cells of *J. virginiana* L. showing nodules on transverse walls and primary pitfields on vertical walls.
7. From transverse section of early wood of *J. virginiana* L. showing intercellular spaces.
8. From radial section of early wood of *Pinus sp.* to show large window-like or primary pitfield.
9. From radial section of early wood of *Picea polita* (Sieb. and Zucc.) Carr. to show piceoid type of cross-field pits.
10. From radial section of early wood of *J. virginiana* L. X *J. Ashei* Buchh. to show cupressoid type of cross-field pits.
11. From radial section of early wood of *Metasequoia glyptostroboides* Hu and Cheng to show taxodioid type of cross-field pits.
12. From radial section of early wood of *Podocarpus Comptonii* Buchh. to show taxodioid type of cross-field pits.

TABLE 1.—SUMMARY OF DATA OF WOOD STRUCTURE

	General					Tracheids—Early Wood							Tracheid Length (Radial Sections)				Intercellular Spaces (X-sec.)	Rays						Parenchyma		
	Young (Y) Mature (M)	G. Rings Indistinct	Htwd. Colored	Odor	Geog. Reg.	Wall Thickness Microns	Lumen Width Microns	Ratio	Cross-Field Pits Cupressoid	Pit Aperture Range Microns	Pit Aperture Ave. Microns	No. of Counts	Range mm	Most Freq. Range mm	Mean	Standard Deviation		(Radial) Horizontal Walls Thin	(Radial) Horizontal Walls "Pitted"	(Radial) End Walls Nodular	(Radial) Indentures	(Tang.) (50 H.P. Fields X 440) Total No. Ray Cells	(Tang.) Range—Cells/Ray	(Tang.) Most Frequent Range	Present	"Abundant"	End-Walls Nodular
Juniperus virginiana L.	M		+	+	N. A.	3.0	27.0	1:9.0	+	6.0	6.0	100	1.58—4.10	2.55—2.94	2.70± .058	.580± .041	+		+	+	+	276	1-14	5	+	+	+
J. Ashei Buchh.	M		+	+	N. A.	5.1	27.0	1:5.2	+	4.5-6.0	4.8	100	1.38—2.63	1.80—1.99	1.94± .031	.310± .021	+		+	+	+	494	1-7	2	+	+	+
J. monosperma (Engelm.) Sarg.	M		+	+	N. A.	3.0	19.5	1:6.5	+	3.0-3.7	3.3	100	.65—2.22	1.25—1.94	1.49± .038	.380± .026	+		+	+	+	480	1-15	2	+	+	+
J. virginiana X *J. Ashei*	Y		?	+	N. A.	4.9	20.1	1:4.1	+	4.5-6.0	4.8	100	.51—1.45	.85—1.04	.89± .021	.214± .015	+		+	+	+	121	1-5	2	+	+	+
J. procera Hochst.	M	+	+	+	Afr.	3.0	15.6	1:5.2	+	6.0	6.0	100	.78—2.99	2.25—2.44	1.97± .043	.438± .031	+	+	+		+	168	1-6	3	+	+	+

ported. Primary pit-fields were noted in the vertical walls, and transverse (end) walls were nodular in all species as observed in tangential sections (fig. 6). No consistent zonation was noted although tendencies from sporadic to a type of zonation about midway in early (spring) wood were observed in transverse sections. Many more samples need to be studied, however, before this feature or the variants observed could be safely applied.

Counts were also made of the number of cells in the uniseriate rays as observed in tangential sections. Fifty microscopic field counts at X440 were made for each species. The most frequent range was five cells in height for *J. virginiana* L., three for *J. procera* Hochst., and two for all the others. The total number of wood ray cells was higher for *J. Ashei* Buchh. and *J. monosperma* (Engelm.) Sarg. than for *J. virginiana* L. The hybrid young wood showed the lowest total number of ray cells.

The data presented in table 1 on tracheid length and on ray height in number of cells would appear to support further the criteria used for specific taxonomic differences among the forms listed.

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COLCHICINE AS A MUTAGENIC AGENT FOR *STREPTOMYCES GRISEUS*

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Several investigators have caused mutations in morphology and in the ability of *Streptomyces griseus* to produce streptomycin with X-rays or ultra-violet light, Waksman and Harris (Proc. Soc. Exptl. Biol. Med. 71: 232, 1949), Appleby (J. Gen. Microbiol. 2: 80, 1948), but use of colchicine as a mutagenic agent has not been reported. Colchicine is a well known agent for producing chromosomal variations in higher plants and might increase either the metabolic functions of the Actinomycetes or produce other aberrations. The culture of *Streptomyces griseus* used for these studies had been maintained in our laboratory several years and showed no propensity for spontaneous variation. Sterile stock solutions of colchicine in distilled water were kept at 4°C in the dark to prevent oxidation to the inactive aldehyde and were used within three weeks. All studies were carried out using concentrations of colchicine ranging from 0.001 to 5.0 percent.

Colchicine was toxic to *S. griseus* as shown by the inhibition or abnormal germination of spores in broth containing the reagent. There is a rough, inverse relationship between the concentration of colchicine and the length of the germ tube or the amount of secondary branching. Washed spores were suspended in broth solutions of colchicine and allowed to germinate at 28°C for 48 hours. Below 0.05 percent colchicine, germination was normal, greater than 90 percent, whereas in concentrations of colchicine from 0.1 to 1.0 percent there was a gradual decrease both in percent germination and branching of the germ tube. The percent germination decreased from 80 percent in 0.1 percent colchicine to 40 percent in 1.0 percent colchicine and no rudimentary mycelial mats formed at concentrations greater than 0.1 percent. The germ tubes were progressively shortened in 1.0 to 4.0 percent colchicine with no branching. Above 4 percent colchicine germination was only 10 percent and germ tubes were mere stubs.

Two methods of determining changes in the colony morphology were used: (1) exposing washed spores to the various concentrations of the reagent, allowing spores to germinate, and then plating them; (2) streaking normal spores on agar plates containing graded concentrations of colchicine. Three types of variation occurred with greater frequency than in the controls. The most frequent variants were normal, well-sporulating colonies with a sector of dead-white, asporogenous hyphae and some entirely asporogenous colonies, such as have been described by other investigators. The second variant was a slow growing asporogenous

colony which first appeared brown and butyrous with sparse aerial hypae. After 20 days the aerial hypae increased in number and length until at the end of 40 days the colony resembled the asporogenous variants. To determine whether this variant arose only after prolonged adsorption of colchicine on the germinating spore, the spores were washed in distilled water prior to plating them. This treatment did not decrease the number of such variants. The third type was a giant form, 19-25 mm. in diameter with otherwise normal appearance which arose only on agar containing 0.002 percent colchicine. None of the abnormal forms were stable and on subsequent transfer all reverted to the normal form.

Attempts to induce physiological variants of *Streptomyces griseus* which would produce abnormal yields of streptomycin were uniformly unsuccessful. Subcultures of normal and variant colonies developing from spores exposed to 0.001 to 5.0 percent colchicine were transferred to a corn steep soybean and Emerson media in shake flasks. The absence of variants with different capacities for producing streptomycin indicates that colchicine is a less favorable agent for this purpose than X-rays or ultra-violet light.

A SIMPLIFIED PLANKTON COUNTING METHOD

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The microscopic assemblage of life in lakes, ponds, streams and rivers, which is made up of both plant and animal forms, is known collectively as plankton. In 1882 Hensen was one of the first to attempt the study of these organisms quantitatively. His investigations were conducted on the Baltic and North seas with nets of various mesh sizes. It was soon found that even the finest meshed nets allowed many organisms to pass directly through.

Sedgwick (1888) and Rafter (1888), recognizing the inadequacy of the plankton net, both described methods of examining water microscopically after concentrating by filtration through sand supported on a bolting silk disk. This method has become known as the Sedgwick-Rafter method and is still widely used today.

In 1911 the extensive limnological program of Birge and Juday was started on the Wisconsin lakes and demanded a still more efficient and practical field plankton sampler. There evolved a portable centrifuge which is now known as the Foerst electric centrifuge. This instrument has been in use for more than thirty years and is recognized by the American Public Health Association, along with the Sedgwick-Rafter method, as the standard procedures for the examination of water and sewage (1946).

Several other devices or modifications, such as the Kofoid filter, the Juday plankton trap, the Clarke and Bumpus quantitative net sampler, have been developed and are in use. However, all require a considerable financial investment in equipment and supplies in addition to the microscope, which is the most fundamental. As a result, many may not have attempted quantitative work on the plankton because of the lack of what appears to be essential equipment. The writer believes that anyone possessing a microscope and an interest in the plankton is in a position to carry on a quantitative study of these organisms. This paper has been prepared with the beginner in mind and is not necessarily directed to the specialist in the field of biological productivity.

That it might be possible to secure reliable quantitative data quickly and without employing expensive equipment was first suggested by Baylis (1922) in a study of the microorganisms in the Baltimore water supply. In 1929, Baylis and Gerstein presented comparative counts made by the Sedgwick-Rafter and the Baylis direct count on the plankton in the Chicago water supply. The data indicated to the writer that the method deserved further consideration. Thus, while an employee of the City of Chicago working with both Baylis and Gerstein, routine plankton determinations were made with the Sedgwick-Rafter method, the Foerst centrifuge, and the direct count on an experimental basis.

Table 1

Order of Counts	Calculated No. of Organisms per ml from 10 areas	Percent Deviation from mean	Calculated No. of Organisms per ml from 50 areas	Percent Deviation from mean
1	1633	7	1962	8
2	2566	46	1555	15
3	1541	12	1700	7
4	1908	9	1695	7
5	2141	22	1805	1
6	1458	17	1927	6
7	1958	12	1860	2
8	991	44	1992	9
9	1933	10	1827	0.3
10	1416	19	1899	4
Mean	1755	20	1822	6

Direct Count Method

As the name implies, the direct count method does not require any concentration or special treatment of the water sample. A Sedgwick-Rafter counting cell or an improvised cell cut from an old piece of a tire inner tube and cemented to a glass slide serves the purpose very well. The usual inside dimensions of the Sedgwick-Rafter cell are 50 by 20 mm but for the direct count it is desirable to increase the area to at least 50 by 40 mm, which means doubling the volume ordinarily observed. Baylis recommends a 5 ml or even a 10 ml cell for making a rapid survey count in which the crustacean or larger organism population is established.

It should be noted that not even the Whipple ocular micrometer is required for the direct count, for instead of counting individual fields the whole length of the cell is traversed and the organisms encountered are enumerated. A minimum of 100 sq mm or two traverses of the 50 mm counting cell are recommended. Four strip counts across a 2 ml cell will increase the accuracy of the method. It is even more desirable to count 100 sq mm in two different 1 ml portions of the original common sample, and such practice should be encouraged. The time required to perform these strip counts is still less than it takes to prepare the samples and determine the count by either the sand filtration or the centrifuge methods.

The factor used for converting a concentrated sample count into actual numbers of organisms per ml is determined as follows:

$$\frac{\text{No. of fields in a 1 ml counting cell 1 mm deep}}{\text{No. of fields examined}} \times \frac{\text{Ml. of final concentrate}}{\text{Ml. of water concentrated}} = \text{The Factor}$$

For the direct count, all that is necessary is to know the area covered by the ocular, the number of fields in the counting cell, and the number of fields examined. Thus,

$$\frac{\text{No. of fields in the counting cell}}{\text{No. of fields examined}} = \text{The Factor}$$

Assuming that you have a one ml Sedgwick-Rafter counting cell (50 x 20 mm) and that you are using a 10 X ocular calibrated so that one field is equivalent to 1 square mil-

limeter, you would then have 1000 ocular fields in the total area of the counting cell. Therefore, if you counted 100 fields the factor would be

$$\frac{1000}{100} = 10 \text{ or the Factor}$$

If your check sheet shows a total of 67 organisms encountered in traversing 100 fields, the total number of organisms per ml of original water would be 670. Varying the size of the counting cell or the number of fields counted would only alter the mathematics involved. It is strongly recommended that the factor be maintained below 10, preferably at 5 or less. It could be accomplished in the example by simply counting 200 instead of 100 fields.

Precision of Counting Methods

The variation in successive counts in the same cell is considerable, even with the standard or approved methods, e.g. Sedgwick-Rafter and Foerst centrifuge. Littleford, et al. (1940) reported variations (table 1) on ten successive Sedgwick-Rafter concentrated counts when varying the areas or fields examined from 10 to 50.

It should be noted that the mean percent deviation in the ten individual counts from a concentrated sample, when 10 areas were counted, was approximately 20 percent with a maximum of 46 percent. By increasing the fields counted from 10 to 50, the mean percent deviation was decreased to approximately 6 percent.

At a rather low population density, the variation in a series of ten individual direct counts on the same one ml quantity of water determined by traversing 100 fields for each count was as follows:

Table 2

Order of Counts	Calculated No. of organisms per ml	Percent Deviation from the mean
1.....	550	12
2.....	410	36
3.....	470	26
4.....	960	51
5.....	790	24
6.....	580	9
7.....	670	5
8.....	530	17
9.....	820	29
10.....	580	9
Mean..	636	22

The mean percent deviation was found to be 22 with a maximum of 51 percent as a possible variation in the ten counts.

With a relative high population density (8000 per ml), ten strip counts across a 50 mm counting cell showed the following variation in actual number of organisms encountered:

Table 3

Order of Counts	No. of Organisms encountered in 50 mm	Percent Deviation from the mean
1.....	333	17
2.....	428	7
3.....	385	4
4.....	439	10
5.....	383	4
6.....	429	7
7.....	481	20
8.....	415	3
9.....	378	6
10.....	341	15
Mean....	401	9

The fact that with a standard method it is possible to get as much as a 46 percent deviation from the mean in its least accurate range would seem to indicate that the direct count with a 51 percent devi-

Table 4—Comparison of Plankton Counts of Lake Michigan Water Made by the Direct Count and the Foerst Centrifuge Methods at Chicago, Illinois, During September, October, and November, 1946.

Month	No. of Samples	Average Number of Plankton per ml		Difference	Percent Deviation from the centrifuge
		Direct count	Foerst centrifuge		
September	50	841	810	31	4
October	29	974	916	58	6
November	29	1268	1179	89	8
Mean	36	1029	972	57	6

ation in its least accurate range might bear consideration and experimentation.

Direct Count vs. Foerst Centrifuge

The first series of comparative counts was made on Lake Michigan water during September, October, and November of 1946. A total of 108 samples was examined for plankton organisms by both the direct count and the Foerst centrifuge methods. An approximately one liter lake water sample was collected and one ml was removed and immediately examined by the direct count. Organisms occurring in 100 fields were enumerated. As the control, one liter of the sample was concentrated to 10 ml by the Foerst centrifuge. One ml of the concentrate was then placed in the counting cell and the organisms in ten fields were enumerated. It is recognized that ten observations are usually considered the minimum when examining a concentrated sample and that the accuracy of the count can be increased by counting more fields. However, 100 fields are likewise considered the minimum allowable for the direct count; therefore, both methods were operating in their least accurate range.

The results show (table 4) that the direct count yielded a slightly higher mean for each month of the study. The percent deviation of the direct count from the centrifuge results increased with the population density from 4 to 8 percent. The direct counts show a mean deviation from the centrifuge results of only 6 percent during the entire three months of the study. It should be emphasized that this difference is the same as found for the Sedgwick-Rafter method when ten successive counts of 50 areas each were made on the same 1 ml of sample (Littleford, 1940).

Daily Fluctuations in Plankton Populations

Monthly averages as expressed in table 4 might leave the impression that the direct count always yielded higher counts than the Foerst centrifuge. Such is not the case. A casual observance of the daily counts found by each method (table 5) reveals what appears to be considerable variation from day to day and likewise between methods.

The problem of marked fluctuations in quantity of plankton from day to day is not new. It is evident in the data presented in most papers on biological productivity. It has been recognized that some of the difference is justifiably due to the precision of the method used. However, the marked similarities of the two curves representing population densities by two different methods seem to indicate that the organisms fluctuate much more than the methods of counting employed (fig. 1). If trends in population densities are the significant points to note, then it would appear that either the Foerst centrifuge or the direct count would serve the purpose equally well.

Table 5.—Comparison of Plankton Counts of Lake Michigan Water Made by the Direct Field Count and the Foerst Centrifuge Methods at Chicago, Illinois, During October, 1946.

Date	Direct	Centrifuged
10-1-46	1455	996
10-2-46	2305	1444
10-3-46	1865	984
10-4-46	600	874
10-5-46	580	796
10-6-46	625	532
10-7-46	395	390
10-8-46	1405	1380
10-9-46	1110	1384
10-10-46	1265	936
10-11-46	595	638
10-12-46	515	534
10-13-46	620	698
10-14-46	530	620
10-15-46	1060	1014
10-16-46	680	554
10-17-46	1130	1160
10-20-46	755	956
10-21-46	1185	1108
10-22-46	1190	1342
10-23-46	1450	1090
10-24-46	1265	844
10-25-46	1345	934
10-26-46	785	690
10-27-46	470	690
10-28-46	620	948
10-29-46	1040	1272
10-30-46	360	814
10-31-46	1060	928
Total	28260	26550
Mean	974	916

Sample Collecting

Verduin (in press) has recognized the inadequacy of the "station method" of sampling in Lake Erie because of the marked fluctuations in the daily counts. He has recommended the use of mobile collecting points which are traversed by boat over rather extensive areas of the lake. By so doing, the migration of the plankton populations can be followed and significance is then attached to the marked day-to-day fluctuations at any station.

If one were so fortunate as to have unlimited funds, the ideal method of sampling a lake or large body of water regularly would be by helicopter. Little time would be lost in moving from point to point and thus an even more accurate representation of plankton population waves or accumulations in specific areas could be established.

It seems quite evident that the method of collecting the sample for examination is probably more important than the selection of a method of counting, if we are to smooth out the daily fluctuations so often reported in plankton studies.

Direct Count vs. Sedgwick-Rafter Method

Beginning March 17, 1947, and continuing through April 15, 1947, plankton samples were collected daily from the raw Lake Michigan water, the chemically treated water, the settled or filtered water and from

TABLE 6.—DIRECT COUNT AND SEDGWICK-RAFTER METHOD COUNT ON WATER OF VARYING POPULATION DENSITIES IN THE SOUTH DISTRICT FILTRATION PLANT OF CHICAGO FROM MARCH 17, THROUGH APRIL 15, 1947.

Kind of Water	Sampling days	Average Plankton No. per ml		Difference
		Direct	Sedgwick-Rafter	
Raw water (untreated)	30	614	414	200
Chemically treated	30	97	35	62
Settled (filtered)	30	11	3	8
Outlet	30	15	6	9

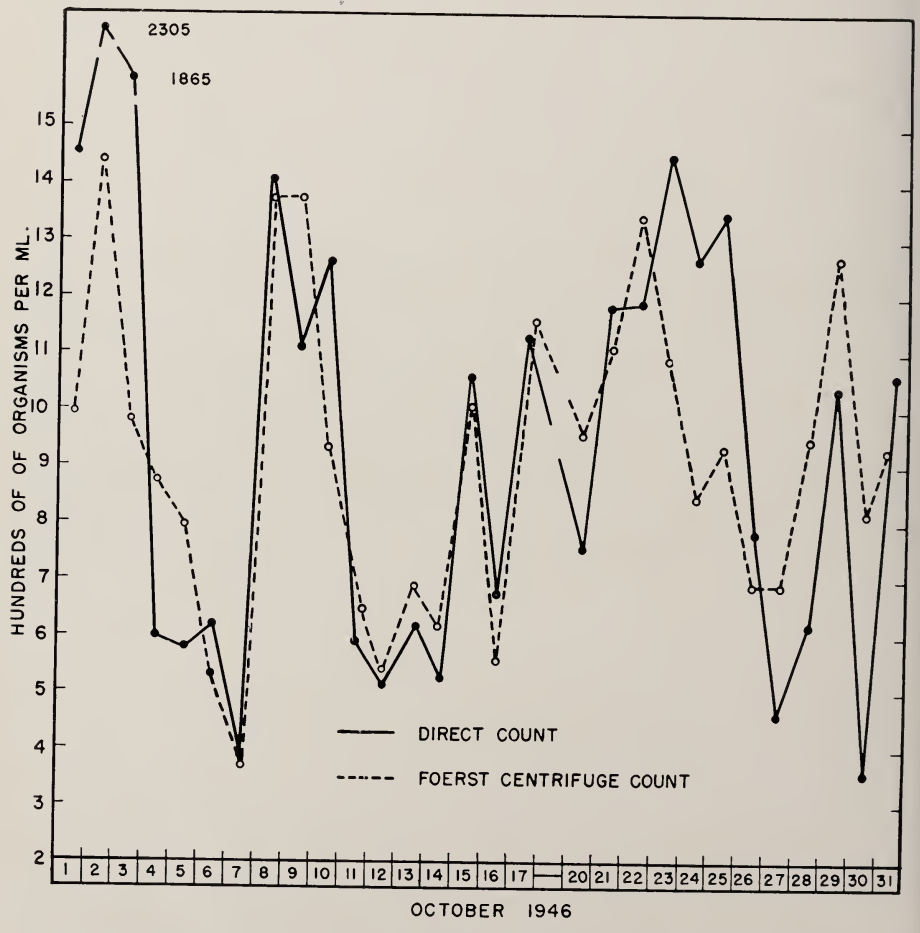

FIG. 1. Comparative plankton counts made by the Foerst centrifuge and the direct count methods on untreated or raw Lake Michigan water during October 1946.

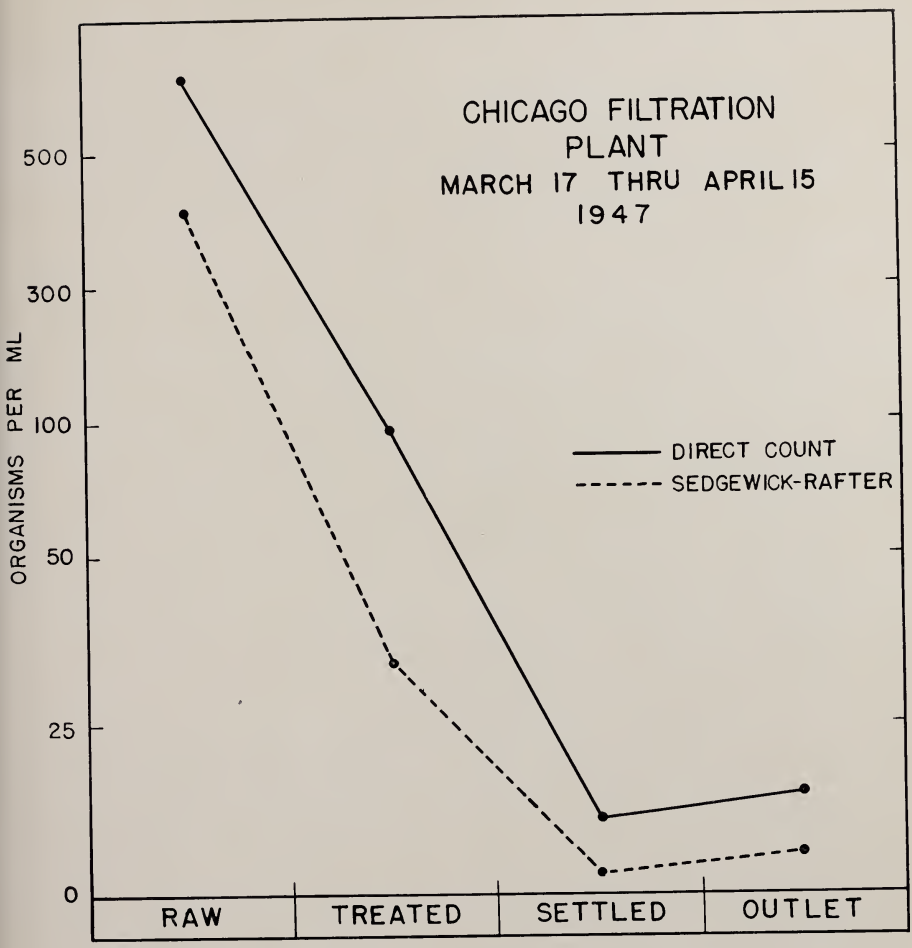

FIG. 2. Comparative plankton counts made by the Sedgwick-Rafter and the direct count methods on water of three different population densities.
Raw—Untreated Lake Michigan water.
Treated—Chemically treated and partially settled water.
Settled—Settled and filtered water.
Outlet—Mixture of treated and settled water.

the outlet water of the Chicago filtration plant. Both the direct count and the Sedgwick-Rafter methods were used on the same common sample. By using the raw, treated, and settled water, the two methods were compared at three quite different population densities. The outlet water during the study was a mixture of treated and settled water.

The direct count yielded a considerably higher average plankton number in all of the population densities (table 6). Yet both curves (fig. 2) followed the same general trend. Which method is nearer to the actual number of organisms present is not of greatest concern. It is important that both methods are consistent. It would appear that for a routine record of the efficiency of plankton removal in a water

plant, the direct count is as reliable as the Sedgwick-Rafter method and is much less time-consuming. For taxonomic or qualitative work on species, a tow net sample or some other means of concentration would always be recommended over the direct count method.

Summary

A simplified method of counting plankton organisms by direct observation without concentration has been described. In routine microscopic examinations over extended periods of time, the results by the direct count have been compared with the Sedgwick-Rafter and the Foerst centrifuge methods.

The data presented seem to indicate that for simplicity, economy, consistency, and convenience the direct count without concentration of the sample is highly satisfactory and often desired over other more involved and expensive methods.

Acknowledgments

The writer is indebted to the Department of Public Works of the City of Chicago where most of the experimental data was collected while he was an employee of the Water Purification Division. Oscar Hewitt is Commissioner of Public Works; W. W. DeBerard is City Engineer; John R. Baylis, Engineer of Water Purification, and H. H. Gerstein, Chief Filtration Chemist at the South District Filtration Plant where much of the laboratory work was completed.

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UTILIZATION OF SOME ORGANIC ACIDS BY *STREPTOMYCES GRISEUS* FOR STREPTOMYCIN PRODUCTION AND GROWTH

C. V. HUBBARD[1] AND H. H. THORNBERRY

Studies on the utilization of some organic acids by *Streptomyces griseus* (Krainsky) Waksman and Henrici, 1943 (33, 35) were undertaken to ascertain further information on the nutritional capacity of this microorganism in connection with streptomycin production. Such studies were favored by the availability of a synthetic medium for the production of streptomycin by this organism (28, 31). They also logically accompany the previous studies on the utilization of some sugars by this organism (17) since both glucose and lactate are important carbon constituents of the chemically defined medium (28, 31). At the time of initiating these studies in 1946, no reference was found relative to this organism utilizing organic acids[2] except malic acid (33).

Methods and Materials

The chemically defined basal medium used throughout these studies was a modification of the original synthetic medium (28) that permitted the addition of organic acids in varied amounts as substitutes for the lactic acid. It consisted of the following constituents of C. P. and Reagent grades:

Substance	Amount	Concentration (Final Molarity)
Glucose (Cerelose)	10. g.	0.0550
KH_2PO_4	2.38 g.	0.0176
$K_2HPO_4.3H_2O$	5.65 g.	0.0247
NH_4NO_3	4.00 g.	0.0500
$Mg\ SO_4.7H_2O$	1.00 g.	0.0040
$Zn\ SO_4.7H_2O$	0.0115 g.	0.00004
$Fe\ SO_4.7H_2O$	0.0111 g.	0.00004
$Cu\ SO_4$	0.0064 g.	0.00004
$Mn\ Cl.4H_2O$	0.0070 g.	0.00004
Distilled water (H-ion concentration adjusted to pH 7.0 ± 0.1 when necessary)	500 ml.	(1000 ml.)

In preparing the complete medium for each of the varied amounts of organic acids (racemic mixtures of the optically active acids), the necessary amounts of the organic acid in aqueous solution neutralized with NaOH to pH 7.0 was added to 75 ml. of the double strength basal medium. Distilled water was then added to make 150 ml. volume. Fifty ml. of this complete medium was then placed in 125 ml. Erlenmeyer flasks in triplicate and sterilized by autoclaving at 121°C. for 15 minutes. The organic acids used were those readily available.

The culture of *Streptomyces griseus*[3] used throughout these studies was a subculture of Waksman's strain No. 9 from No. 18-16 origi-

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[2] Referred to as acids rather than sodium salts of organic acids for brevity.

[3] Letter from S. A. Waksman to H. W. Anderson, September 1, 1944.

nally obtained from heavily manured field soil (26).

Other items of procedure involved the following methods and conditions:

(a) The inoculum, consisting of 3 or 4 drops of suspended fragments of mycelium, was applied to the surface of the medium (17).

(b) Growth conditions consisted of surface stationary culture (air surface of 0.5 cm^2/ml. of medium 2 cm. deep) and 26°C. for 10 days.

(c) Growth in 10 days was estimated qualitatively on an arbitrary scale of 0 to 10 and where adequate it was determined quantitatively as vacuum dried (80°C.) mycelial mat weight.

(d) The pH values were determined with a glass electrode Beckman pH meter.

(e) Streptomycin was determined in duplicate assays by the paper disc-plate method against *Bacillus subtilis* cultured at 30°C. (19). The fermented medium was diluted 1-4 in 0.1 molar phosphate buffer at pH 7.8 for the assays. Streptomycin values are reported as "S Units" of streptomycin per ml. (34). One "S Unit" of streptomycin is approximately one microgram of streptomycin free base (36).

(f) The effect of the nutritive acids on the assay of streptomycin was measured by mixing the acids individually at 0.1 molal final concentration with solutions of streptomycin six hours prior to assay in the usual procedure.

(g) The effect of these acids upon growth of the test organism in the assay plates was determined by applying them individually at 0.1 molal to the assay discs as in (f) above but without streptomycin.

Experiments and Results

For a preliminary survey on utilization, some organic acids were each evaluated at 0.05 molal in the basal synthetic medium. The results in table 1 indicate that some acids are not utilized at 0.05 molal. In fact, these acids either retard or inhibit the growth of *Streptomyces griseus*. These are butyric, a-hydroxy-e-benzoylamino caproic, monochloroacetic, crotonic, glycollic, formic, mandelic, oxalic, and tannic acids. Some other acids either do not affect the organism or affect it too slightly to yield noticeable comparative changes in pH, growth, or streptomycin production from the control of basal medium. These are tartaric (Na and Na and K salts) and tartronic acids. Other acids appear to be utilized. These are acetic, adipic, citric, glutaric, lactic (control), malic, malonic, and succinic acids.

Those acids that did not noticeably inhibit or retard growth at 0.05 molal were evaluated over a range of concentration. It was thought that results from this procedure should reveal whether utilization of organic acids might be related to concentration or to a suitable balance of these substances with other constituents in the medium. The results are given in charts (figs. 1 to 10) in order to show the relationship of three responses (pH, growth, and streptomycin production) to concentration of nutritive acid. These responses do not necessarily parallel each other or show any constant relationship with respect to either concentration or type of acid. The composite results in the charts indicate that these acids are utilized in some manner and to some extent by the organism in its metabolism under these conditions.

TABLE 1.—UTILIZATION OF ORGANIC ACIDS AT 0.05 MOLAL BY STREPTOMYCES GRISEUS IN STATIONARY CULTURE AT 26°C.

Acid	pH Initial	pH Final	Growth (10 days)	Mat weight (mg)	Streptomycin (units/ml)
Acetic	6.88	7.74	8	274	52
Adipic	6.83	6.92	10	323	48
Butyric	6.72	6.55	0	...[a]	0
a-hydroxy-e-benzoylamino caproic	6.83	6.0	3	...	20
Monochloroacetic	6.35	6.3	0	...	0
Citric	6.79	8.25	4	...	52
Crotonic	6.8	6.62	0	...	0
Formic	6.78	6.61	3	...	0
Glutaric	6.85	6.60	10	285	53
Glycollic	6.78	5.8	7	...	24
Lactic	6.75	7.96	10	442	61
Malic	6.85	8.5	10	357	63
Malonic	7.0	6.82	10	325	37
Mandelic	6.7	5.95	1	...	0
Oxalic K salt	6.64	5.38	2	...	12
Oxalic Na salt	6.83	5.84	2	...	18
Tannic	6.8	6.5	0	...	0
Tartaric Na salt	6.94	6.17	9	260	39
Tartaric Na K salt	6.7	5.69	8	...	31
Tartronic	6.82	6.2	8	250	36
Succinic	6.9	8.40	10	425	83
Control	6.71	6.25	9	205	46

a. Value not determined.

Alkalinity of the medium in all cases except for two organic acids (tartaric and tartronic acids causing only minor changes) increased with the increase of nutritive acid concentration up to an optimal concentration at about 0.1 molal. Growth in all cases was related to the nutritive acid concentration. The optimal concentration was found to be about 0.05 molal for acetic, citric, and glutaric; about 0.1 molal for adipic, lactic, malic, succinic, tartaric, and tartronic; and about 0.3 molal for malonic acid. Streptomycin yields evidenced by the assays indicated that the concentration of nutritive acid influenced production. Only lactic acid supported sizable production of streptomycin. Its optimal concentration was 0.1 molal.

The effect of these utilizable acids upon the growth of the test organism in the assay plate is nil. Their effect on the assay of streptomycin is practically nil. These results, as means of six determinations, are summarized by expressing them as a ratio of the size of zones of inhibition from streptomycin with acids to that from streptomycin alone—"Acid/Control Index." The computed "Acid/Control Indices" for the acids are acetic 1.02, adipic 1.04, citric 1.02, glutaric 0.90, lactic 1.01, malic 1.08, malonic 1.06, succinic 1.04, tartaric 1.00, and tartronic 1.05. These indices are based upon a mean 17.75 mm. zone of inhibition for the streptomycin control.

DISCUSSION

The discussion offers some summary interpretations from the overall results on three measured responses of the organism; it presents some

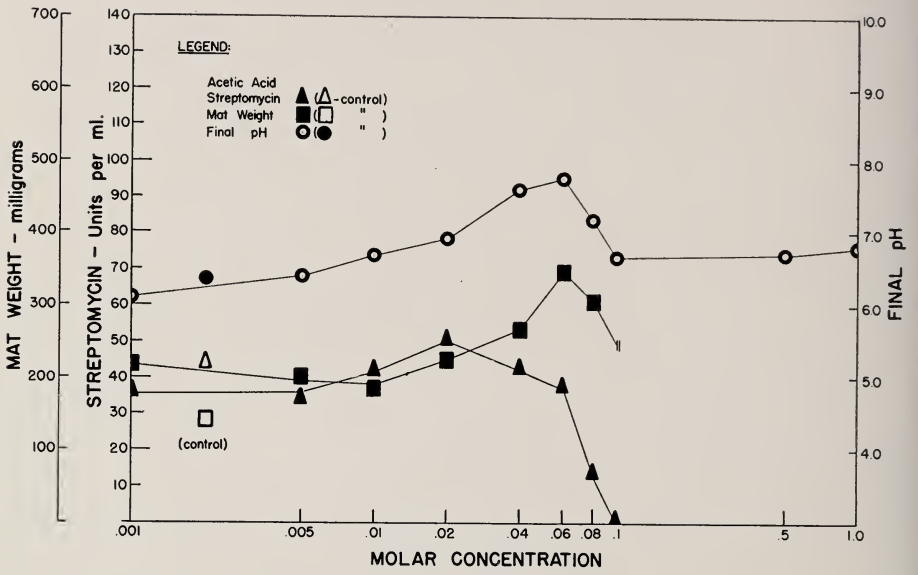

FIG. 1.—Effect of acetic acid at varied concentrations on *Streptomyces griseus* in stationary culture at 26° C.

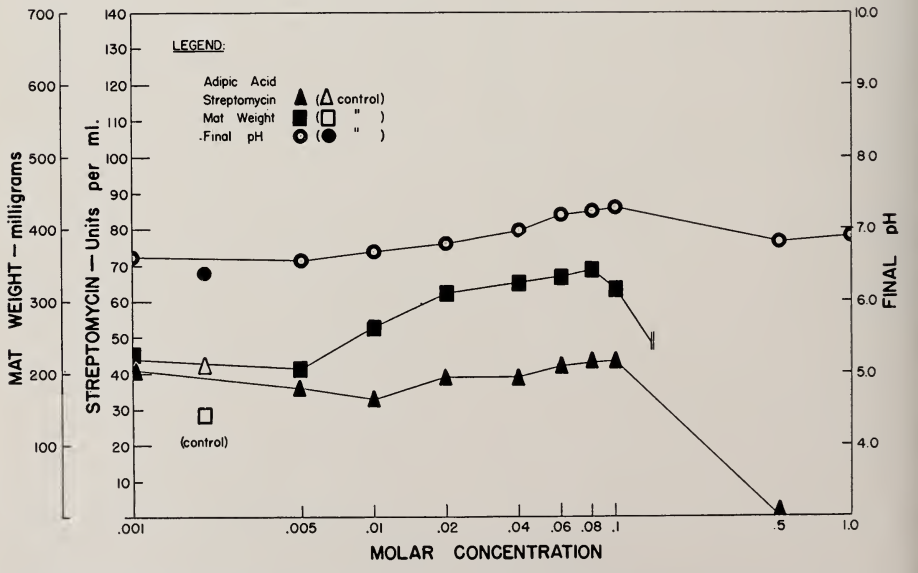

FIG. 2.—Effect of adipic acid at varied concentrations on *Streptomyces griseus* in stationary culture at 26° C.

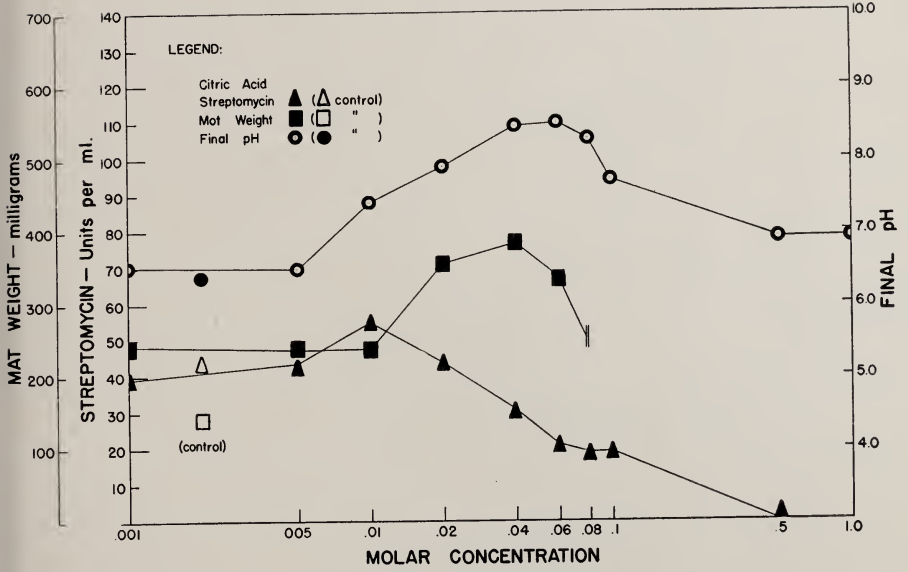

FIG. 3.—Effect of citric acid at varied concentrations on *Streptomyces griseus* in stationary culture at 26° C.

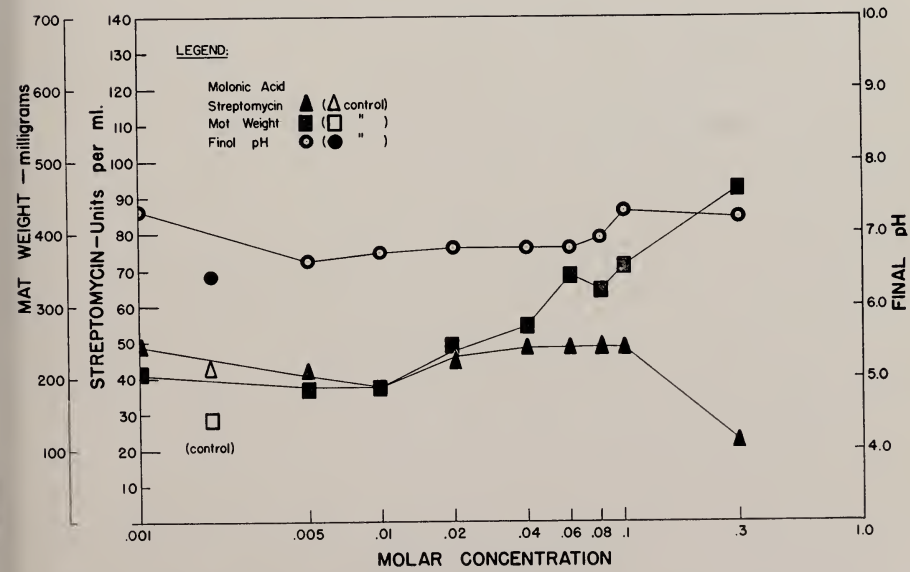

FIG. 4.—Effect of malonic acid at varied concentrations on *Streptomyces griseus* in stationary culture at 26° C.

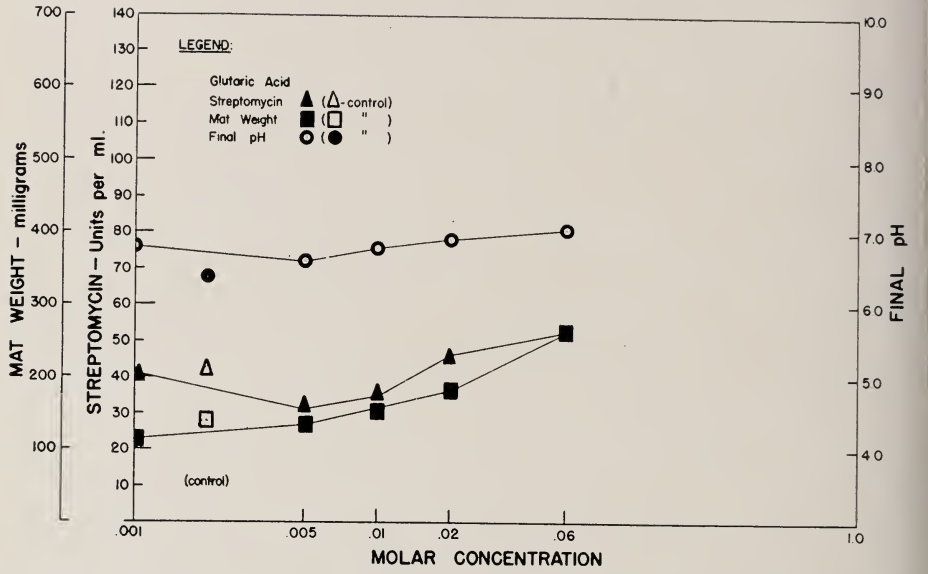

FIG. 5.—Effect of glutaric acid at varied concentrations on *Streptomyces griseus* in stationary culture at 26° C.

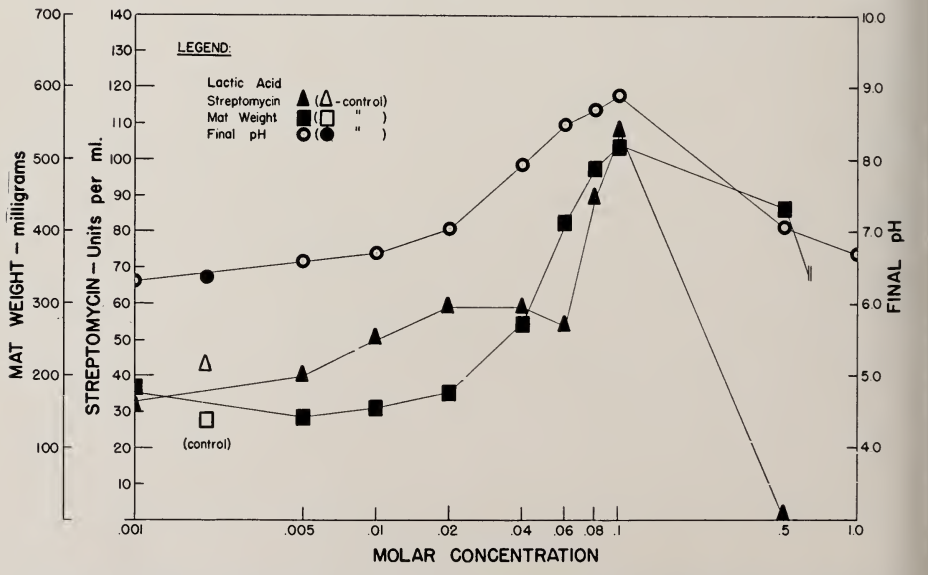

FIG. 6.—Effect of lactic acid at varied concentrations on *Streptomyces griseus* in stationary culture at 26° C.

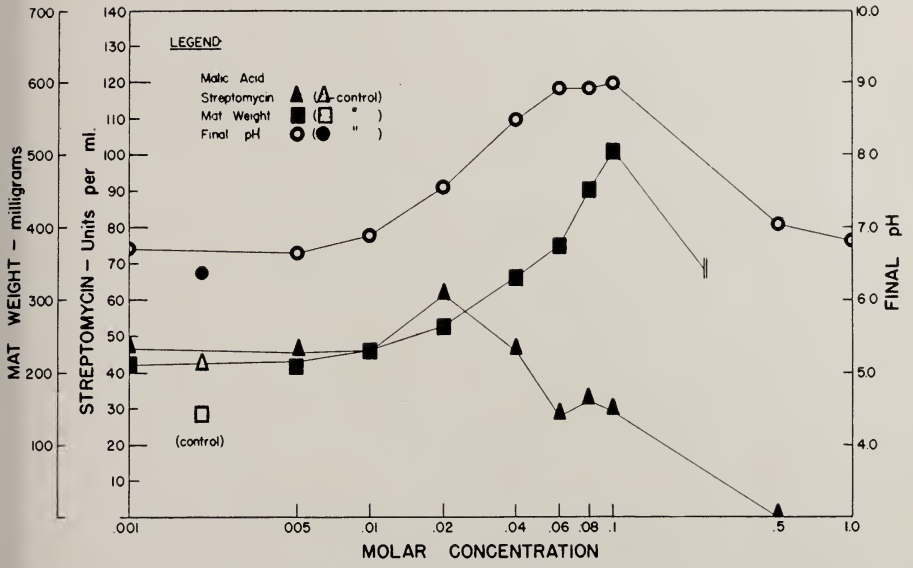

FIG. 7.—Effect of malic acid at varied concentrations on *Streptomyces griseus* in stationary culture at 26° C.

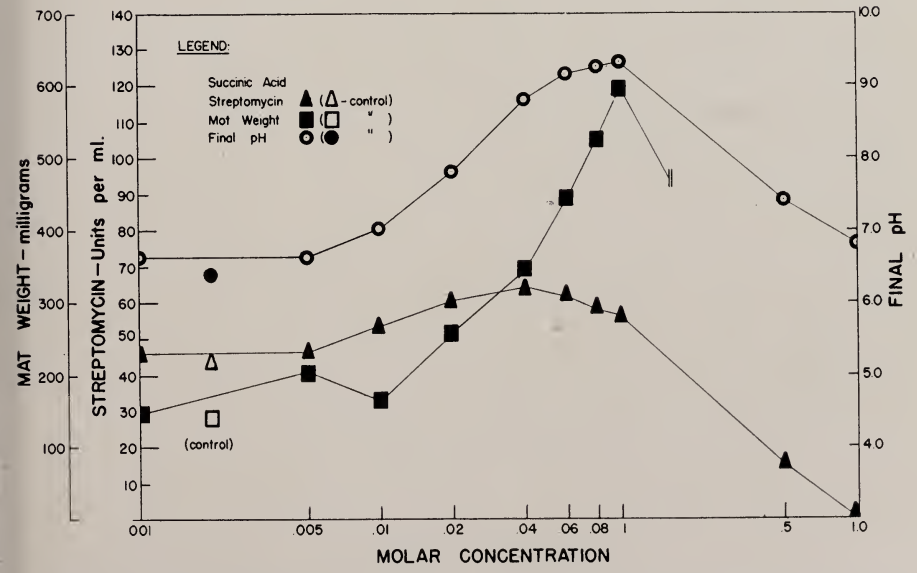

FIG. 8.—Effect of succinic acid at varied concentrations on *Streptomyces griseus* in stationary culture at 26° C.

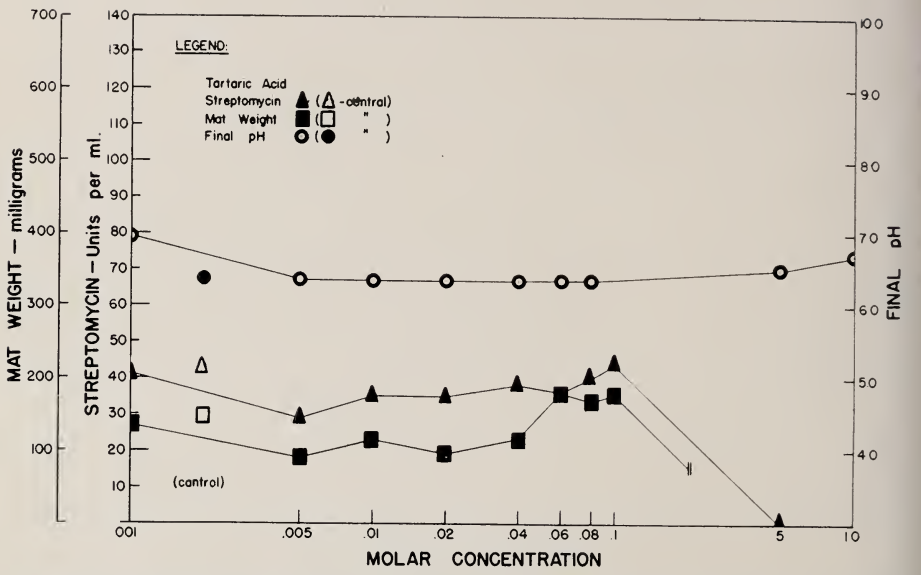

FIG. 9.—Effect of tartaric acid at varied concentrations on *Streptomyces griseus* in stationary culture at 26° C.

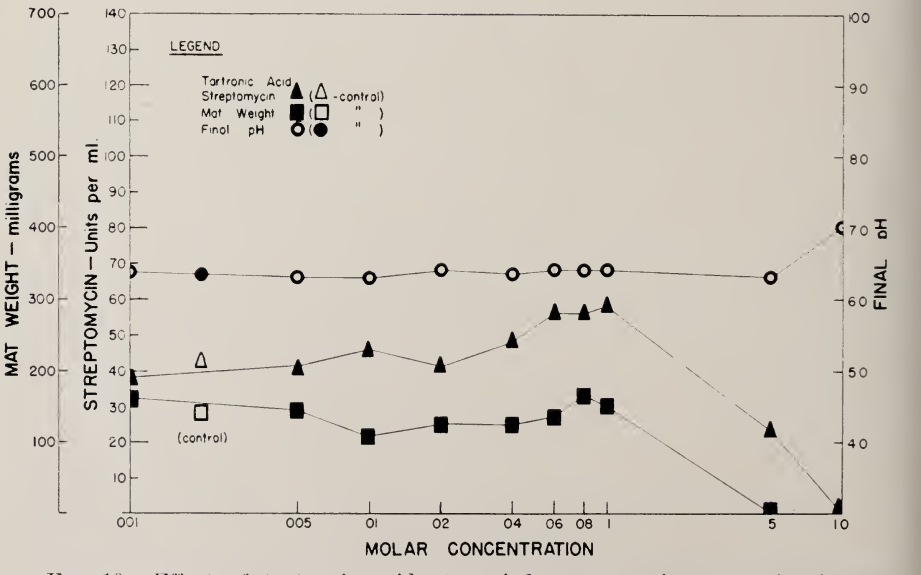

FIG. 10.—Effect of tartronic acid at varied concentrations on *Streptomyces griseus* in stationary culture at 26° C.

considerations with respect to safeguards against artifacts in the data; it advances some speculations relative to the role of trace elements for organic acid utilization, to organic acids influencing metabolic mechanisms, and to lactic acid in streptomycin synthesis. The speculations are included for the sole purpose of attempting to keep the small sector represented by this study oriented at least toward the composite picture of microbial metabolism.

The results from this study extend the information relative to the assimulative and dissimulative capacity of *Streptomyces griseus* for sources of carbon beyond some sugars (17). Although the results are based upon indirect criteria for utilization, they contribute to a preliminary qualitative survey of carbon sources. In addition, the results establish certain basic information by designating some growth inhibitive acids and by indicating differences among utilizable acids.

The three measured responses (pH, growth, and streptomycin production) associated with the metabolism of the organism appear to show a maximum at some range of concentration of each organic acid except for (a) pH in the medium containing glutaric, tartaric, and tartronic acids and (b) streptomycin production in media containing glutaric acid. In the case of glutaric acid, the highest concentration used may have been inadequate to indicate an optimal concentration. An optimal concentration is apparent for each of the other organic acids in the medium as has been found for sugars (17) and for various constituents of the synthetic medium (28, 31). Since these respective optimal concentrations for the three responses occur, for the most part, at different amounts of the acids, they suggest that different metabolic mechanisms are involved in these responses. Similar unparalleled responses are evident in connection with the optimal concentrations of sugars (17) and constituents of the original synthetic medium (28, 31). They have been noted under some other conditions (9, 12). However, the three responses were somewhat parallel with lactic acid, the optimal concentration of which was 0.1 molal for each response.

The H-ion concentration of the medium being related to the balance among ionizable acidic and basic substances at the time of the pH measurements would result from the accumulation of either the residual materials following the assimulation of original constituents of the medium or the end products of metabolism. Metabolites that are consumed as they are produced by the organism would not appreciably affect pH. Thus, the measured increase in alkalinity apparently originates from the accumulation of basic sodium ions or basic end products in the medium. Either of these accumulations would indicate utilization of the acids since the alkalinity is relative to the original concentration of nutritive acid in the medium. It is doubtful whether tartaric and tartronic acids are utilizable (figs. 9, 10). This agrees with another report claiming non-utilization of tartaric acid (23). It is apparent that all the other acids tested at varied concentrations are utilizable (figs. 1 to 8). If organic acids are produced during metabolism, it would appear that these are in turn utilized. It has been reported that organic acids are not produced by Strain No. 4 of *S. griseus* (6) and that the end product of metabolism

of this organism in submerged culture is CO_2 rather than organic acids (8). By escape of this gaseous end product there would be a tendency for any basic non-volatile residues and end products to overbalance the acidic residues and metabolites in the medium. Such could account for the rise in alkalinity usually encountered with this organism. However, if the concentration of glucose is particularly high in a synthetic medium, the reaction does not become more alkaline but becomes acid during fermentation for a period of time (31).

Growth responses of the organism, since they are affected by concentration of the acids, appear to be satisfactory evidence of utilization of these substances. By combining these responses with the somewhat parallel responses in alkalinity changes, these criteria for utilization become more reliable. Growth is better on lactic, malic, and succinic acids than other acids.

Streptomycin production according to the activity detected by the assays is not appreciably increased by any of the acids except lactic acid, a constituent of the original synthetic medium (28,31). Although production from the other acids was not great, there appears to be some relationship of streptomycin yield to concentration of the acids (figs. 1 to 10). Because these optima for streptomycin production with the exception of lactic acid are not the same as those for growth, it appears that the optimal concentration of such nutrients for growth may be "out of balance" for streptomycin production. Along this reasoning, lactic acid at 0.1 molal is "in balance" with other nutrients for growth and streptomycin production simultaneously. As lactic, malic, and succinic acids contributed marked responses in pH and growth, with streptomycin being produced in any appreciable amount only from lactic acid (figs. 6, 7, 8), it appears that lactic acid may specifically contribute to the production of streptomycin by this organism. Mechanisms of metabolism or nutrition favoring the production of lactic acid might conceivably stimulate growth of the organism with appreciable production of streptomycin, whereas good growth without lactic acid being supplied or produced in the medium might result in low yields of streptomycin.

Neither the assay of streptomycin nor the growth of the assay organism on the assay plates was appreciably affected by any of the organic acids at 0.1 molal. However, it has been reported that salts of some of these acids antagonize the action of streptomycin (3, 4, 7, 10, 13, 14, 16) and also effect the growth of test organisms for assay (7, 18, 36). These discrepancies may be explainable in differences among the test organisms used or conditions of the assays. In the paper-disc assay plate method only substances that would diffuse faster than the streptomycin would be able to affect the test organism. In addition, the method is insensitive to substances such as alcohol that might affect the test organisms suspended in a liquid culture (30).

The osmotic concentrations of the various media do not solely influence the optimal concentrations of acids since the optima did not occur at any one concentration. However, the physical effect of the higher concentrations (0.615 molal for 0.5 molal acids) would be expected to influence the functions of the organism (physiological salt solution being 0.155 molal NaCl although based

upon human red blood cells). Since abrupt changes in the responses occurred generally at 0.1 molal (0.215 total molal concentration), the isotonic concentration of the organism (although undetermined) would be expected to be slightly above this total molal concentration. It has been reported that a reduction of NaCl concentration in the medium accounts for a relatively greater amount of streptomycin recoverable from the mycelium than from the medium (9). According to this, the higher concentrations of sodium salts of the organic acids where reduced streptomycin production occurred should favor the release of streptomycin into the medium and thus permit adequate assay of the streptomycin actually formed. Sodium chloride has been reported to stimulate the production of streptomycin in a soybean medium (25).

The relation of trace elements in the medium to the utilization of organic acids is not apparent from the observations and data of this study. However, in other studies trace elements in a medium containing both glucose and lactic acid influenced growth and streptomycin production (28, 31). Also the minerals remaining in the ash of some animal and plant products stimulated growth and streptomycin production (29). In addition to influencing the growth of microorganisms, trace elements are known to alter the metabolism of microorganisms so as to favor the accumulation of commercially desired end products of metabolism such as citric acid (22). Even without the presence of organisms, they can catalyze the oxidation of sugars to organic acids in acid or alkaline solutions when molecular oxygen is supplied (11). They also increase the ionization and reactivity of sugars as acids (11). These phenomena and the fact that some organic acids are utilized by *S. griseus* and other actinomycetes (2, 33) suggest that this organism may utilize organic acids through some mechanism involving metallic trace elements.

Lactic acid appears to play a role in streptomycin production by *S. griseus*. The acid is known to function in CO_2 fixation by *Clostridium butylicum* (5). Carbon dioxide appears to be necessary for some actinomycetes in synthetic media (1) and either CO_2 or the carbonate radical appears to influence streptomycin production by *S. griseus* (31). A lactic acid forming enzyme is inactivated at 37° C. (20), the temperature at which *S. griseus* does not produce streptomycin even though good growth continues (31). Since lactic acid is rapidly consumed by *S. griseus* (31) and is unique among the acids studied for streptomycin production, the synthesis of streptomycin by this organism might conceivably be dependent upon lactic acid which may be supplied to the medium or produced by the organism itself for assimulation or dissimulation (31).

Any effect of streptomycin upon the metabolism of *S. griseus* which produces it is not directly revealed by the data. However, the data do suggest some presumed evidence and inferences for streptomycin effects. Since streptomycin appears to affect the oxidation of acetate by *Escherichia coli* (21) and animal tissue homogenates (32), streptomycin might conceivably influence the oxidative system of *S. griseus* with respect to organic acids if these acids should be broken down to a two-carbon acid such as acetic (15). Such an influence might retard further

synthesis of streptomycin even though growth is excellent when the medium contains nutrients of particular substances such as malic and succinic acids. If lactic acid should afford other or additional mechanisms, the synthesis of streptomycin might not be retarded when lactic acid is available. This would explain the occurrence of higher production of streptomycin from lactic acid than from other acids when growth is approximately equal on the acids concerned.

Another possible explanation is that the acids other than lactic may channel the mechanisms of the organism away from streptomycin synthesis or may direct the mechanisms into streptomycin utilization. Lactic acid, on the other hand, may channel the mechanisms away from streptomycin utilization and toward streptomycin synthesis. Streptomycin is utilized by some microorganisms (24) but no report was found where an organism could produce streptomycin or an antibiotic under some conditions and under certain other conditions could utilize it.

It should be kept in mind that a supposedly pure culture of this organism may mutate into strains (27) or carry strains that possess quite distinct functional characteristics. Such inductions or selections might be brought about by the organic acids in the medium, as growth in these experiments involves successive generations from a small quantity of the inoculum. Organic acids in certain respects might be considered as metabolites which could be more effective than the less oxidized aldehydes (sugars as conventional carbon sources) in influencing metabolic mechanisms. Organic acids are end products of metabolism of many microorganisms (22, 37) and even species of *Streptomyces* (6). The absence of organic acids detectable as end products (6) does not necessarily mean that *S. griseus* is incapable of producing organic acids. It has been reported that *S. griseus* forms very little acid from glucose and no succinic acid during active growth although traces of succionate appear in later stages of growth (6). Organic acids might be formed but if they are rapidly utilized they would not become concentrated sufficiently for detection by usual methods of analysis. The evidence for utilization of organic acids reported herein and mentioned above (6) suggests that organic acids may be significant nutrients or metabolites that influence streptomycin production.

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CHEMISTRY

METHOXYL DETERMINATIONS ON ALKYL ESTERS OF 2-METHOXYBENZOIC ACID*

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In the course of another investigation it became desirable to ascertain to what extent certain alkyl ester groups would interfere with methoxyl determinations made on derivatives of methoxy-aromatic acids.

The Zeisel method in its various modifications has long been used, on both macro and micro scale, for the determination of methoxyl and ethoxyl groups; with certain changes in apparatus and technic, it has been recommended for propoxyl and butoxyl determinations[1]. It might be inferred, therefore, that a methoxyl determination by the usual procedure could be carried out without interference by pentoxyl groups. That this is not the case is shown here.

The ready availability of salicylic acid made it convenient to use as a starting material for the preparation of suitable test compounds. This paper reports the preparation and properties of the n-propyl, n-butyl, and n-pentyl esters of 2-methoxy benzoic acid, and results of methoxyl determinations made upon them by the micro Zeisel method.

Of the simple alkyl esters of 2-methoxybenzoic acid, only the methyl[2] and ethyl[3] esters have been described in the literature.

Experimental

2-Methoxybenzoic acid. This compound was prepared by methylating salicylic acid with dimethyl sulfate and purifying the product according to the method of Graebe[4]. One mole (138 g.) of salicylic acid yielded 95.3 g. of 2-methoxybenzoic acid (62.7% of theoretical); recovery of salicylic acid was 32.8 g., making the yield of desired product 81.8% based on salicylic acid actually used. The melting point was 101.5-103.5°C. after recrystallization from water.

Esters of 2-methoxybenzoic acid. As typical of the method used, the preparation of n-butyl 2-methoxybenzoate is described here. The procedure was essentially that used by Cavill and Gibson[5] for making n-butyl 4-methoxybenzoate. A solution of 30.4 g. (0.2 mole) of 2-methoxybenzoic acid in 100 ml. of n-butanol and 100 ml. of toluene was treated with 10 drops of concentrattrated sulfuric acid, and refluxed until no more water accumulated in the graduated trap which was interposed between the flask and the condenser. In about three hours 4 ml. of water were caught (theoretical 0.2 mole = 3.6 ml.). The reaction mixture was cooled, washed with water, sodium carbonate solution, water, dried over anhydrous sodium

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[1] See, for example, Sidney Siggia, "Quantitative Organic Analysis via Functional Groups," p. 30, John Wiley and Sons, Inc., 1949.

[2] See Beilstein, "Handbuch der Organischen Chemie," 4th Edition, Vol. X, p. 71; 1st Supplement X, p. 32.

[3] Ibid. Vol. X, p. 74; 1st Supplement X, p. 34.

[4] Ann. *340*, 210; *139*, 137; cf. Beilstein X. p. 64.

[5] G. W. K. Cavill and N. A. Gibson, J. Soc. Chem. Ind. *66*, 274, 1947.

TABLE I.—METHOXYL DATA FOR 1, 2-C_6H_4 (COOR) (OCH_3).

R	Theoret. OCH_3	—OR found (as —OCH_3)	Flushing time (Minutes)	Number of alkoxyl groups
n-C_3H_7	15.98	30.16	45*	1.89
n-C_4H_9	14.90	28.28	45*	1.90
n-C_5H_{11}	13.96	17.64	20	1.26
n-C_5H_{11}	"	26.72	80	1.91
n-C_5H_{11}	"	27.16	90	1.95

* Approximate.

sulfate, the butanol and toluene distilled off, and the product distilled at diminished pressure. The yield was 38.3 g. or 92% of the theoretical. This was redistilled through a short column prior to analysis. Boiling point, 112°C. at 1.2 mm.; f.p., —23° to —25°; n_D^{20}, 1.51125; d_4^{20}, 1.062. Analysis: Calcd. for $C_{12}H_{16}O_3$: C, 69.21; H, 7.74. Found: C, 69.22; H, 7.68.

The n-pentyl ester, prepared in a similar manner from 15. 2 g. (0.1 mole) of 2-methoxybenzoic acid, 25 g. of pentanol-1, 75 ml. of toluene and 3 drops of sulfuric acid, was isolated in 69% yield. B.p., 112-13° at 0.8 mm.; n_D^{20}, 1.50668; d_4^{20}, 1.045. Anal.: Calcd. for $C_{13}H_{18}O_3$: C, 70.24; H, 8.16. Found: C, 70.03; H, 8.19.

In the preparation of the propyl ester, 150 ml. of benzene were used in place of toluene, with 30.4 g. of the acid, 60 ml. of propanol and 2 ml. of sulfuric acid. The crude ester, 37.1 g. or 95.6% of theoretical, required several redistillations before it was sufficiently pure for analysis. B.p., 114.8-115.5° at 1.5 mm.; n_D^{20}, 1.51566; d_4^{20}, 1.085. Anal.: Calcd. for $C_{11}H_{14}O_3$: C, 68.02; H, 7.26. Found: C, 67.88, 68.10; H, 7.44, 7.44.

A small sample of each of the esters was saponified and the 3, 5-dinitrobenzoate was prepared from the alcohol formed. The derivatives thus produced were those of the normal alcohol proving that no rearrangement of the alkyl groups had occurred during esterification.

Methoxyl determinations were run essentially as described by Pregl[6], with variations in the length of the flushing period. Table I gives the results of these determinations, and shows the effect of varying the fushing period in the case of the pentyl ester.

It is thus shown that even with the normal 20-minute flushing period, the presence of n-pentyl ester groups results in a high value for methoxyl, and that with longer flushing periods, both ether and ester alkoxyl groups in these compounds can be determined with a fair degree of completeness.

SUMMARY

Three new compounds have been described and their physical constants reported. These are the n-propyl, n-butyl, and n-pentyl esters of 2-methoxybenzoic acid.

In all cases the alkoxyl groups present as esters have been split off with hydriodic acid, and the resulting alkyl iodides have distilled over along with methyl iodide from the ether group in the micro Zeisel methoxyl procedure.

[6] Pregl-Grant, "Quantitative Organic Analysis," p. 146, The Blakiston Co., 1946.

THE KOLBE ELECTROCHEMICAL SYNTHESIS: AN ACADEMIC TOPIC

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The electrolysis of organic-acid salts initiated by Kolbe in 1849 remains one of the most direct approaches to the study of free radicals. The concentrated potassium acetate which he first used is excellent for demonstrating this experiment. This solution is made by saturating water with solid potassium acetate and adding about five percent of the volume of glacial acetic acid. It is both anolyte and catholyte. The cathode is copper wire gauze. The anode is platinum foil, secured through a rubber stopper in a porous cup. A glass tube through this stopper permits the gaseous products of the electrolysis to escape from the reaction chamber. They pass through a U tube containing glass beads and 6 N. aqueous NaOH solution, then through another U tube containing glass beads and conc. H_2SO_4; thence they are led to a pneumatic trough for collection. Neither dimensions of the apparatus nor concentrations of the solutions are critical. Also the electrolyzing voltage may vary within rather wide limits. It may be as little as 8 volts or even less if the experiment may be started some hours ahead of class time; but if 15 to 20 volts[1] are available, the experiment may be started with the start of the lecture, and will in a few minutes yield sufficient ethane for a burning test. It is one of the few organic chemistry experiments well-adapted for lecture demonstration.

To interpret it from the free-radical viewpoint is a fine exercise in visualization of molecular behavior. The starting material is acetic acid; the products are cathodic hydrogen, and anodic carbon dioxide and ethane, mainly; though some ethylene, methanol, and methyl acetate are also formed at the anode. The following sequence of events is presumed to explain these results:

(a) Before electrolysis—ionization of solvent and salt, the former only slight.

(b) At cathode—arrival of cations K^+ and H_3O^+, with selective discharge of latter (see activity series) with production of H_2.

(c) At anode—arrival of anions $CH_3 \cdot COO^-$ and OH^-, with selective discharge mainly, but not exclusively, of the former, producing the free radicals $CH_3 \cdot COO$ and OH[2]. Each of these contains an odd number of electrons.

(d) Decomposition of some $CH_3 \cdot COO$ into CH_3 and CO_2, (and some OH into O_2 and H_2O). The new free radical thus formed contains also an odd number of electrons.

(e) The formation of all possible stable combinations of the three free radicals present. The radicals are (1) $CH_3 \cdot COO$, (2) CH_3, (3) OH. The stable products predicted and found are: $CH_3 \cdot CH_3$, $CH_3 \cdot COO \cdot CH_3$, and CH_3OH, besides the CO_2. In the demonstration, the NaOH in

[1] External cooling is advisable with higher voltages.

[2] The $CH_3.COO.OOC.CH_3$ and HO.OH postulated as intermediates in current theories of this synthesis would be in equilibrium, theoretically, with the two prime free radicals.

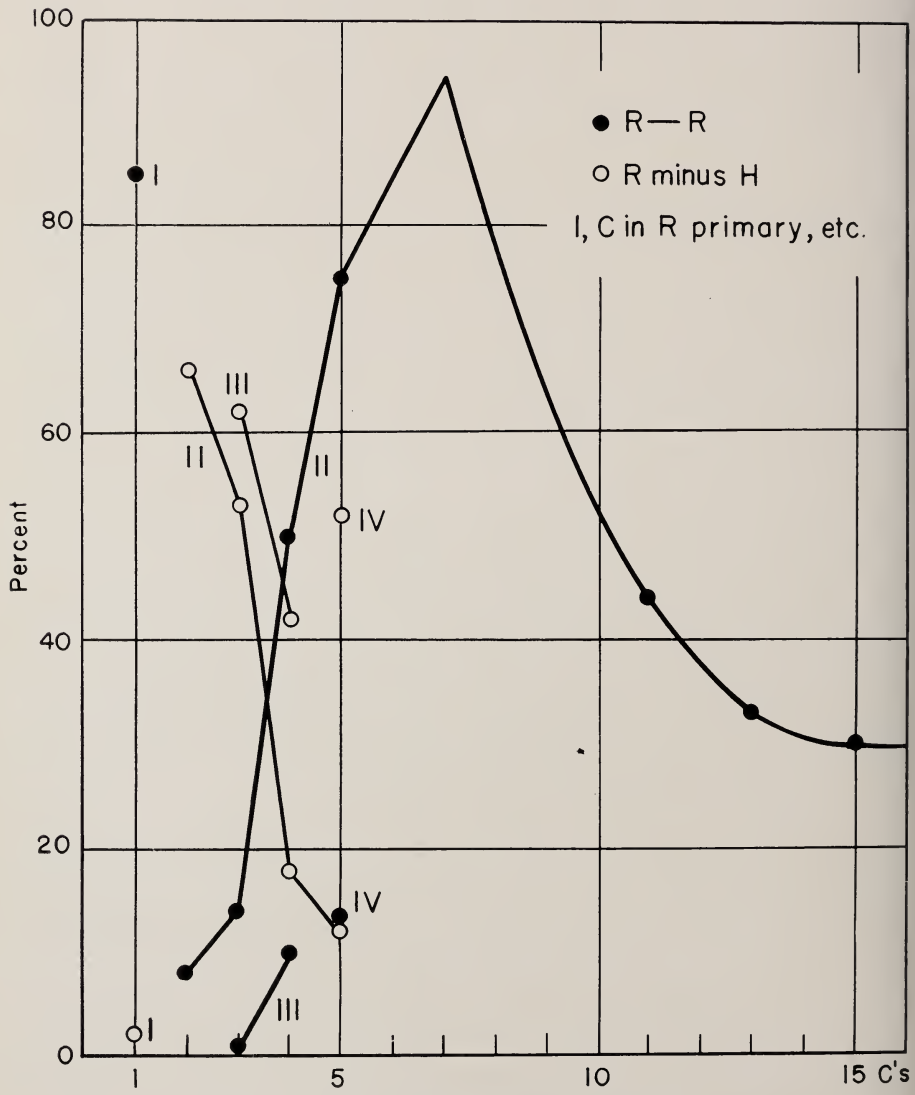

Fig. 1.—Current yields vs. number of C's in R.

the first U tube removes the CO_2. All the stable products have even numbers of electrons.

(f) The loss of H atoms from some of the CH_3 radicals. Since each H atom carries an electron, this leaves the new CH_2 radical with an even number of electrons, so it is a reaction which should tend to occur. The methylene dimerizes to C_2H_4, which is removed from the ethane by the H_2SO_4 in the second U tube.

It is also helpful to visualize this electrolysis of acetic acid in relation to two very familiar pyrolyses of the same substance. Thus,

(a) acetate ion + alkali ion + thermal energy → methane + carbonate.

(b) acetate ion + alkali ion + electrical energy → ethane + carbon dioxide + hydroxide ion (formed at cathode when H_2 is liberated).

(c) acetate ion + alkaline-earth ion + thermal energy → acetone + carbonate.

Since, of course, the carbonate or hydroxide can be converted to the starting salt by adding more acetic acid, with evolution of CO_2 if the carbonate was formed, all three processes are decarboxylations of acetic acid; and the effect of the different metals, together with the directive action of the electrical field, may be compared as a study in catalysis.

Further, the Kolbe synthesis is the basis of interesting speculation. By analogy to the first example, R · COOK should yield R · R abundantly, whatever the nature of R ·, with a little (R minus H), ROH, and R · COO · R. This is not true. Even when R contains nothing but C and H, and is saturated, the proportions of the products are highly variable. Thus, potassium propionate yields very little n-butane, but produces ethylene (R minus H) copiously. As the homologous series is pursued, results intermediate between these two extremes appear. This is shown graphically in figure 1, in which the number of carbon atoms in R is plotted against percent current[3] yield. (The data here plotted are taken from table VIII, p. 43 of item (2) of the bibliography.) Solid circles designate R · R; open circles (R minus H). The roman numbers designate the type of carbon atom attached to the carboxyl group. In acetic acid, it is primary (I), being attached to only one other carbon. In the straight-chain acids propionic to stearic,[4] it is secondary (II). For this series most data were available. Only a pair of tertiary acids were tabulated, and only one quaternary. The following generalizations can be deduced from figure 1:

(a) The yield of R · R is an inverse function of the yield of (R minus H).

(b) The type of carbon atom attached to the carboxyl determines the family to which an acid belongs in this synthesis.

(c) The extra CH_2 group acquired in converting a secondary carbon atom to a tertiary does not greatly alter the yield, since curves III could nearly be superimposed on curves II by shifting the abscissa one unit to the left.

(d) The maximum yield of R · R might be expected in about the

[3] The current yield is chosen rather than the material yield because it is more easily defined. This is because the cathode action forms ions equivalent to KOH in its vicinity, and the solution tends to become alkaline as electrolysis progresses; and when the hydroxide ion concentration reaches the anode, hydroxide discharges ever more readily and production of $CH_3.COO$ radicals falls off. To prevent this, excess of the free acid whose potassium salt is being electrolyzed is maintained in the system.

[4] Off the scale of figure 1, but on the curve.

region of octanoic acid, where the data fail.

(e) Acetic acid is an isolated, rather than a typical, case.

(f) The production of (R minus H) is about as typical as the production of R · R.

More speculation may be centered about the role of unsaturation in this synthesis. As a product, it is common. When it is initially present, it inhibits the synthesis. It does this by raising the discharge potential of the organic anion, making it relatively easier to discharge hydroxyl. Straight-chain double bonds. if nearer to the carboxyl than the delta atom, usually prevent the synthesis from occurring. Benzenoid double bonds have a similar action. Fichter and Stenzl used pyridine, alone or with methyl alcohol, as a solvent for this synthesis, and thus provided solvent anions much more difficult to discharge than hydroxyl. In these solvents they were able to convert benzoic acid to diphenyl, and phenylacetic acid to dibenzyl.

It is interesting to note that some 4-phenylpyridine was recovered in the electrolysis of benzoate in pyridine. This is for this system analogous to ROH in water, and suggests that pyridine ionizes by disengaging a hydrogen atom at the point most remote from the nitrogen, and that if other ions are also produced, this is the one most easily discharged. As a rough approximation, unsaturation is a fairly typical product; its initial presence operates against the formation of more, according to Le Chatelier's theorem.

Since the ethylenic double bond is a ring system of two atoms, the behavior of larger ring systems is of interest. Such systems with three, four, and five carbon atoms in the ring, and the ring adjacent to the carboxyl group, have been investigated. Only R · COO · R and ROH seem to evolve in significant amounts. This suggests: (a) the organic discharge potential is somewhat raised, so that it is about comparable to that of hydroxide, so that liberal amounts of both R · COO and OH are present together; (b) the rate of decomposition of R · COO into R and CO_2 is lowered, so that considerable R and R · COO exist together.

Finally, the synthesis offers a wide field for investigation. Decomposition potentials, material yields, and gas analyses are largely unrecorded, except for the first three members. Other solvents besides pyridine, methyl alcohol, and water might be investigated. The effect of the alicyclic ring more remote from the carboxyl appears to be unknown. The effects of temperatures and pressures much greater than atmospheric have not been studied. Much may possibly be done by a careful literature search; the earliest work is so old that copies or direct abstracts of it are not available in the smaller chemical libraries. For many experimental studies no especially difficult apparatuses or techniques are needed. A study of the electrolysis of mandelate ion, $C_6H_5 \cdot CHOH \cdot COO^-$, is offered as an example. Since this is a substituted acid, it might be well to note these recorded results for such; R is listed:

(a) Forms R · R · abundantly: acetyl, o-nitrophenyl.

(b) Forms (R minus H) abundantly: α-hydroxy ethyl, α-hydroxy proply, β-hydroxy propyl, ∂-gluconyl, allo-camphoryl, phenyl hydroxy methyl (which is the R of the mandelate ion).

The case of R being $C_6H_5 \cdot CHOH$ was investigated by Walker in 1896,

using an aqueous solution.[5] He records the production of only small amounts of hydrobenzoin $C_6H_5 \cdot CHOH \cdot CHOH \cdot C_6H_5$, but a considerable amount of benzaldehyde, C_6H_5CHO. Since the former is the RR product and the latter is (R minus H), it is evident that mandelic acid, $C_6H_5 \cdot CHOH \cdot COOH$, resembles propionic acid rather than acetic acid in regard to behavior of its ion in a Kolbe electrolysis. Walker suspected that the hydrobenzoin resulted from the cathodic reduction of the benzaldehyde. It is, of course, possible to take the converse view and assume that the benzaldehyde results from the anodic oxidation of the hydrobenzoin. Oxygen thus used would come from discharged hydroxyl ions from the solvent water. This proposition was tested by using the technique of Fichter and Stenzl to electrolyze the mandelate ion in non-aqueous solvent. The potassium salt in methanol-pyridine, and the diethylammonium salt in pure pyridine, were both tried.

An undivided cell was used. A small copper beaker held the electrolytic solution and served as a cathode. A platinum anode was supported by a glass tube led through a three-hole rubber stopper into the cell. Gas was led to a Burrell analyzer from a tube inserted in another bore of the stopper. The temperature of the mixture was maintained at 24°C. by external cooling with ice water. A typical reaction mixture was 51 ml. of 1 N. methanolic potassium hydroxide, 38 gms. of mandelic acid, and 51 ml. of pyridine. About 40 volts were used to maintain about 0.7 amperes of current. When a gas analysis was not desired, a larger electrolysis vessel, consisting of a 400 ml. tall-form beaker, was used. A spiral copper tube carrying water was the cathode, and a rotating platinum spiral was the anode. Coulombs would be passed in excess of the theoretically required amount. Several runs from the large cell would be combined for isolation of the organic products, by usual techniques, substantially as outlined by Fichter and Stenzl. Again much benzaldehyde was found, and very little hydrobenzoin. That some of the latter was present was proved by the precipitation of silver iodate from a solution of silver ions and periodic acid, a test quite specific for 1, 2 dialcohols. Moreover, by working up the material from the proper point in the organic separation scheme, a small amount of substance was prepared by reaction with benzoyl chloride, which gave the proper melting point for the dibenzoate of hydrobenzoin. Since pyridine alone gave no appreciable amount of hydrobenzoin, and since pyridine could not possibly release anode oxygen since it contains none, it could not be argued that the benzaldehyde resulted from the oxidation of the hydrobenzoin. Rather, the prime stable compound formed from the free radicals was of the (R minus H) type.

The average of several gas-analysis experiments was expressed as a ratio of H_2 to CO_2 equal to 0.8, the individual values varying from 0.763 to 1.075. Remembering that both cathodic and anodic H_2 is registered and that 2 faradays make 1 gram-molecular volume of cathodic hydrogen and 2 g.m.v. of anodic CO_2, we see that this ratio should be

[5] It is surprising that $C_6H_5 \cdot CHOH \cdot COO^-$ ion discharges in aqueous electrolysis, since $C_6H_5 \cdot CH_2 \cdot COO^-$ does not. Apparently, although the double bonds in the molecule tighten the terminal electron, the hydroxyl oxygen loosens it.

0.500 for a perfect RR synthesis; but if each radical that furnished a CO_2 furnished addionally $\frac{1}{2}H_2$, the ratio should be 1.00. Also, any discharge of solvent anions would increase this ratio by cutting down its denominator more extensively than the numerator. The picture supported by the gas analysis therefore is that of extensive (R minus H) synthesis, accompanied by some $R \cdot R$ formation.

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A SPHERICAL ARRANGEMENT OF THE CHEMICAL ELEMENTS*

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Chemical literature includes many periodic tables, charts, or other means of classifying the chemical elements. Some have involved a great deal of work. Others may not have been so laboriously prepared. But the purpose in them all has been to establish a satisfactory correlation of chemical knowledge as related to the physical and chemical properties of the elements.

A study of these various periodic arrangements will show common failings to be either that of placing different elements on the same position in the chart or placing a group of elements outside the chart, as is commonly done with the rare earths.

A few authors have attempted to overcome these difficulties. The spherical arrangement suggested by Friend (1) and the helical form proposed by Harkins (2) are outstanding. We have found, however, that a more desirable organization is obtained by using both helical and spherical arrangements together in the same system.

This arrangement is outlined below and takes the form of a sphere. The upper hemisphere includes most of the known elements. Only a few elements at the begining of the lower hemisphere are known, and thus it is largely theoretical and extrapolated on the basis of the following reasonable assumptions.

Assumptions.—The two assumptions on which the construction of the complete sphere is based are: first, that the actinide series, when completed, will resemble the lanthanide series (3); and second, that the pattern outlined in the upper hemisphere of the system will repeat itself, decreasing the way it built up, to an end. Here a hypothetical element with an atomic number of 172 would come in as the last element. This element would have an electronic configuration of: 2, 8, 8, 18, 18, 32, 32, 18, 18, 8, 8, 2. The equator of the sphere would arbitrarily come between the sixth and seventh periods.

The pattern.—The following description outlines the organization of the complete sphere, including both the top hemisphere containing the known elements and the extrapolated theoretical lower hemisphere.

The sphere is divided into twelve latitudes, six in each hemisphere. The first seven latitudes compose the seven known periods, the seventh being incomplete at present. The remaining five latitudes are theoretical and serve to complete the pattern on the sphere. There are eight longitudinal bands (groups), two of which originate and terminate in the first and last latitudes; these are groups I and VIII (the inert gases).[1]

* Presented before the Chemistry Section of the Illinois Academy of Science at Galesburg, May 6, 1949.

[1] Since the elements in the various groups hold group numbers corresponding to the number of electrons in their outermost shell, it seems reasonable to label the inert gas group as group VIII, for helium is the only inert gas without eight electrons in its outermost shell, having but two electrons; this eliminates the designation "zero." For simplicity, the nine elements of the so-called group VIII may be designated the "Triad System," of group VIIIB, for they lie between groups VII and I, are not inert, and range in valence from one to eight. If C and D groups were attached to the triads, it would indicate that they are inert elements; and, of course, group VIII is the only group that can have inert elements in it.

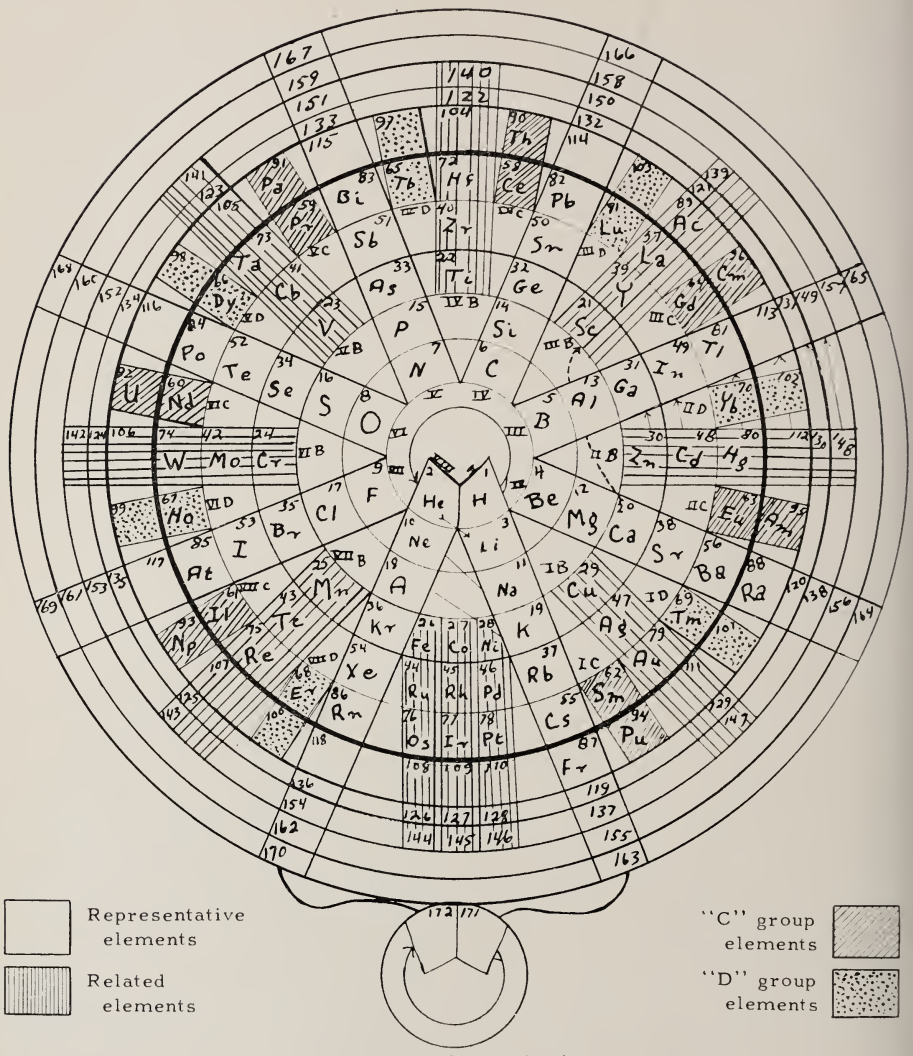

FIG. 1.—A polar projection.

The other groups originate and terminate in the second and eleventh latitudes. These eight longitudinal bands comprise the eight groups of representative elements. Group I, which cuts twelve latitudes, is immediately followed by groups II through VII, which cut ten latitudes, and then group VIII, which cuts twelve latitudes, as the first group. Between the eight main groups lie the ten B groups, originating in the fourth and ending in the ninth latitude, B groups eight, nine, and ten forming the triad system and lying between the main groups VIII and I. In each case the B group is placed after the main group to which it is related. Attached to the B groups (with the exception of the triad system) will be found the C and D groups on the left and right, respectively. These short groups, C and D, start in the sixth latitude and

end in the seventh latitude, the latitudes on either side of the "equator." Each period has its beginning in group I with the elements placed in a counterclockwise order. The last element in each period is found in group VIII, with the inert gases.

The elements with atomic numbers 21 through 30, inclusive, might be thought of as the calcium series, since it is from that element in period four that there is the deviation into the B groups, even as the elements deviating from lanthanum are known as the lanthanide series. The rare earth elements fill the C and D groups of the sixth period. Going backwards one element from lanthanum, one finds barium, from which the twenty-four succeeding elements deviate from the main group. Hence, this could be considered the barium series, which would be composed of the lanthanide series and the ten elements in the B groups that are part of this period. The deviations in latitudes six and seven are the same, and the deviations in latitudes, or periods, four, five, eight, and nine would be the same.

The transition points.—The system starts with hydrogen in group I, period (and latitude) one, and rotates counterclockwise until it reaches helium, the first inert element and the end of the first period. From the end of a period the transition is consistently to the element in group I in the next lower latitude. When period four is reached, the transition is not so simple, involving a total of five types of transition points.

The first transition point is from helium to lithium, period one to period two. The second and third transition points are the connections between the representative elements and the related elements of group A and group B. In period four, group II is the first transition point of this type: from calcium to scandium, and returning to the main groups from zinc to gallium. Once transition is made into the B groups from the representative elements, only the B groups are touched in the counterclockwise rotation until group IIB is reached, where the normal transition is to the main group III and the period is completed with an inert gas. The fact that an element is in a B group would indicate inner building in the second from the outermost shell. (See fig. 2, cross-cut view of period five.) These transition points are involved in periods four through nine, inclusive.

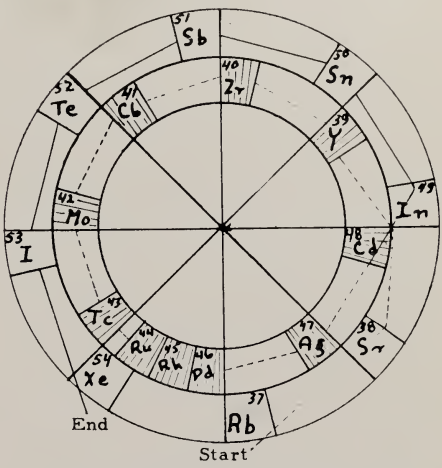

FIG. 2.—Period five, cross-cut view.

However, the transition points previously mentioned, although they apply to periods six and seven, become a little more complex with the introduction of transition points four and five. These transition points involve the departure from the B groups in group IIIB, period six, and the return from IIID to IVB. To illustrate: from lanthanum (IIIB, period six) to cerium (IVC,

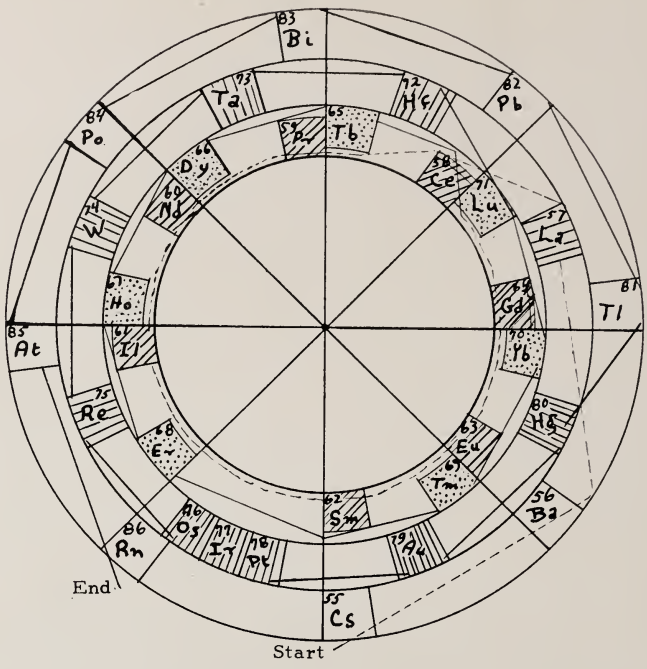

Fig. 3.—Period six, cross-cut view.

period six), and from lutecium (IIID, period six) to hafnium (IVB, period six). It is pointed out here that the transition from gadolinium (IIIC, period six) to terbium (IVD, period six) is not considered a transition point, since it is merely completing the lanthanide series. (See fig. 3.)

The fourth and fifth transition points form a system similar to the transition system involving the B groups, except that this group of the elements, C and D groups, gain electrons in the third from the outer shell. The last element in the lanthanide series ends with element number 71, and this element is in IIID, where both C and D groups are filled. The building in the third from the outermost shell is almost completed in this element. Next the B groups are filled and finally the main groups. Period seven, just across the equator of the system, is assumed to be similar to the sixth period. From p e r i o d seven to twelve, the number of elements in each period decreases in the same manner in which they reach the maximum. The transition points of all periods of the same length are the same throughout the entire system.

Theoretical basis for the treatment of the lanthanides.—A certain degree of periodicity in valence is found when the lanthanides are plotted as they are in figure 4. This is in agreement with the periodicity brought out by Moeller's (4) atomic volume plot of the lanthanides, and in Van Rysselberghe's "New Periodic Table" (5). The circled valences in figure 4 indicate valence states either of minor importance or of those unobtainable in the presence

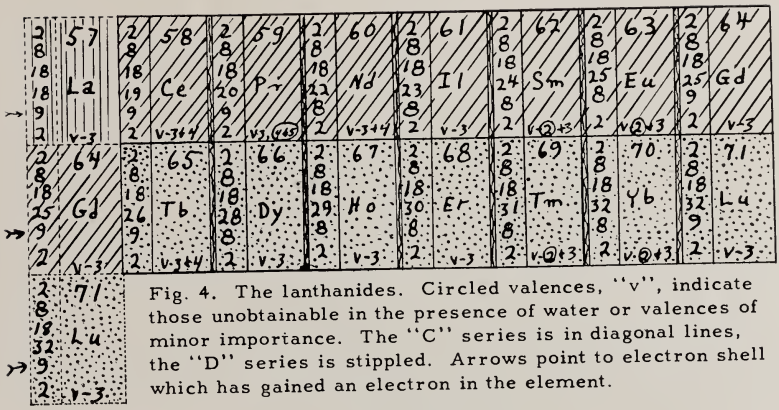

Fig. 4. The lanthanides. Circled valences, "v", indicate those unobtainable in the presence of water or valences of minor importance. The "C" series is in diagonal lines, the "D" series is stippled. Arrows point to electron shell which has gained an electron in the element.

FIG. 4.—The lanthanides.

of water. These pairs of lanthanides were attached as C and D groups to the B groups in period six, excluding the triad system. Their variance in valence is generally similar to that of the B group to which they were attached; this is part of the basis for attachment to the B groups. The lanthanides are thus included in period six, which has 32 elements. Position in the C and D groups shows relation to the B groups and more or less remote relationship to the elements in the main groups.

Attention is called to gadolinium and lutecium, attached to lanthanum, because they gain an electron in the second from the outermost shell as does lanthanum. Lutecium is more closely related and similar to lanthanum because of the fact that its third shell is complete like that of lanthanum (6).

A letter in *Nature* (7) points out that divalent compounds of both europium and ytterbium exhibit a strong blue fluorescence when exposed to ultra-violet light; these elements are attached to group IIB in period six and are one of the pairs formed in figure 4.

Theoretical basis for the treatment of the actinides.—Certain of the actinides, attached immediately below the lanthanides and on the opposite side of the equator of the spherical system, have for some time been considered as properly belonging to the B groups of the related elements (8). For example, thorium has been considered to belong to group IVB. In the spherical system this element is appropriately attached in a C group, maintaining its relationship to group IV, and also in accord with the modern concept of thorium as part of the actinide series (9). This same relationship is observed in the case of protactinium, in group VC, and of uranium, in VIC, which are attached to their respective B groups.

The lanthanides and actinides are thus attached to the B groups in such a way that their relationship to the other elements is evident, and yet their individuality is retained by their placement in C and D groups.

Interpretation of the diagrams.—Figure 1 is a polar projection of the sphere. A study of it will show that the equator of the system lies between periods six and seven. The

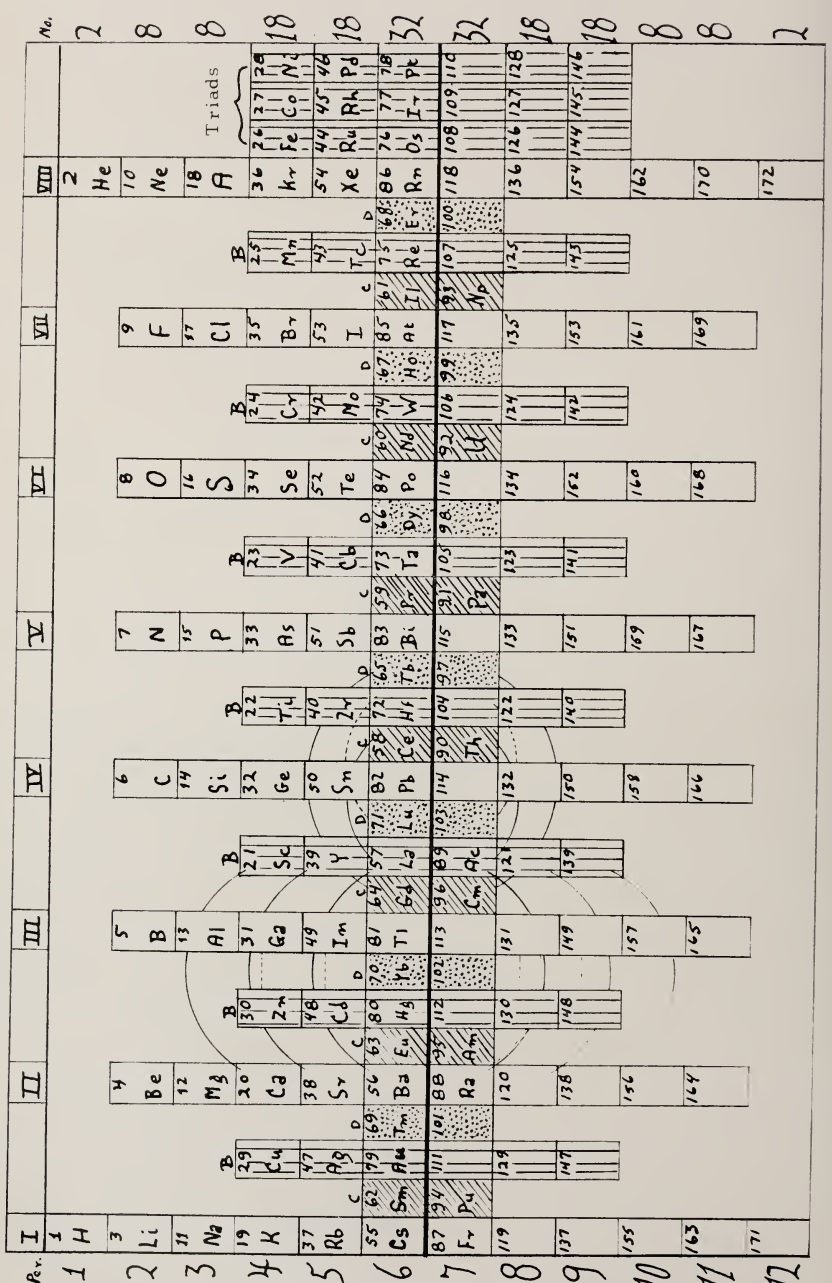

Fig. 5.—A Mercator projection.

pattern of the lower hemisphere is extended in a manner similar to the way in which the upper hemisphere built up to period six with its 32 elements, but in reverse: starting with the seventh period filling out to 32 elements and the following periods having 18, 18, 8, 8, and 2 elements. The key is the same in all the diagrams. A white background denotes the representative or main elements (A groups). A vertically lined background denotes the related elements (B groups), and slant-lined and stippled backgrounds denote the C and D series respectively of the "rare" elements, the lanthanide and actinide series. The heavy black line indicates the equator of the system. In figure 1, the theoretical, extrapolated periods eight, nine, ten, and eleven are reduced in size so that they may be included.

Figure 2 gives a cross-cut view of period five, and figure 3 of period six. These two diagrams show how the elements build up in the spherical system, and suggest analogous positions of electrons in the particular latitude of electrons building up.

Figure 4 shows the periodicity in the lanthanides in regard to valence; and the electrons in the various shells as well as the valence states are included in the diagram. Figure 5 is a Mercator projection of the spherical system.

Advantages.—a. The number of elements in each period is easily ascertained, since it is known that the periods contain respectively 2, 8, 8, 18, 18, and 32 elements.

b. The inert gases, elements which have all their electron shells filled, are placed at the end of their respective periods.

c. The representative elements, those with all but the outer shell filled, stand out clearly.

d. The related, or B group, elements are placed adjacent to and following the group to which they are related.

e. The "rare" elements, the lanthanide and actinide series, are placed in C and D groups showing three incomplete electron shells and showing their relation to the B group elements and through these to the representative elements. Elements in B groups show building in the second from the outer shell, and those in C and D groups show building in the third from the outer shell.

f. Interpretation of the periodicity of the elements, in terms of electronic configuration, is greatly facilitated, position in the sphere being directly related to electronic configuration.

g. Erroneous analogies between A and B group elements are avoided, and family relationships are clearly emphasized.

h. Elements of any specific group retain their distinctive characteristics, and at the same time show their relationship to the other elements in the group, as B, C, and D group elements.

i. The lanthanide series is included in the system in a satisfactory way, and its relation to the other elements and the periodic table is clearly shown.

j. There is a logical continuity within the system.

Summary.—A new arrangement of the atoms is described which has a combined helical and spherical organization. The system incorporates the representative, the related, and the rare earth elements in one sequence and in correct relationships to the other atoms. A theory concerning the electronic configuration of the undiscovered elements is presented.

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GEOGRAPHY

GEOGRAPHICAL POSSIBILITIES OF CORK PRODUCTION IN THE UNITED STATES

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Scattered cork oaks growing in southern and southwestern states may prove to be the forerunners of an important cork production industry in the United States. The cork oak is indigenous to the Mediterranean region, the present center of world cork production, and trees from that region have been introduced into the United States. They represent various spasmodic attempts by the government, educational institutions, and interested individuals to establish the cork oak in this country.

Need for Cork

The need for cork in American industry was shown when the War Production Board listed it as one of fifteen critical materials essential to keeping the wheels of production turning. Even before the attack on Pearl Harbor, American supplies of cork were placed under strict regulation to channel them into defense and essential civilian usage. Cork gaskets and washers are "must" parts in keeping grease and oil at work lubricating machines. Among other uses of cork are insulation, corkboard, bomb parts, submarine linings, and life preservers.

> Cork is one of those versatile natural materials, like leather, that can do a lot of jobs well, and for which there is no single acceptable substitute . . . . The freeing of North Africa, and the bettering of the shipping situation to Mediterranean ports on the European side have relieved the cork situation considerably. Nevertheless, our recent unpleasant experience has taught us a sharp lesson and it will be far better, no matter what kind of improved world the peace may usher in, not to leave ourselves in a position to be caught in the same fix again.[1]

The exigencies of the early years of World War II plainly showed that cork production in the United States would be economically desirable if it could be proved geographically possible.

Present Distribution

The world cork supply comes from a region about the size of New Jersey. This region of intensive production lies within an area stretching for more than 1000 miles along the western part of the North African coast. In Europe the region stretches from the Landes area of France around the Iberian Peninsula in a narrow fringe along the Mediterranean to the toe of the Italian boot. Figure 1 shows the location of the Mediterranean region cork producing areas, for which the 1936 production statistics are given in table 1. This is the latest year for which full statistics for all countries are available. Incomplete figures for 1941 show small increases in production, but the only available postwar information indicates a small reduction following wartime peaks in Portugal and Spain.[2]

[1] Frank Thone, "Cork in Bottleneck," *Science News Letter*, XLIV (October 16, 1943), p. 247.
[2] Private communication with Spanish and Portuguese Embassies.

TABLE 1.—CORK OAK ACREAGE AND CORK PRODUCTION, MEDITERRANEAN REGION—1936[3]

Area		Country	Annual Production		
% of total	Acres (000's)		Short tons (000's)	% of total	Yield lb./acre
33.8	1,720	Portugal	130.0	46.2	151
12.2	622	Spain	66.0	23.1	212
21.6	1,100	Algeria	38.5	13.8	70
14.6	741	French Morocco	17.6	6.3	48
6.9	350	France, Corsica	13.2	4.8	75
4.9	247	Italy, Sardinia, Sicily	8.8	3.2	71
4.6	235	Tunisia	7.4	2.6	63
1.4	74	Spanish Morocco*	.....	.....	.....
100.0	5,089	Mediterranean Region	281.5	100.0	112

* Included as a potential producer.

GEOGRAPHIC FACTORS IN CORK GROWTH

The geographical possibilities of cork production in the United States are intimately related to temperature, rainfall, and soil. It was found that the cork oak grows: (1) equatorward of a composite line based on the 37° F. January and the 50° F. annual surface isotherms; (2) at annual surface temperatures between the limits of 50° F. and 70° F.; (3) under an annual rainfall between the limits of 10 and 60 inches; and (4) in a variety of soils ranging from semi-arid brown steppe soils to the moist tropical and subtropical red and yellow soils.

To translate these facts to the American scene, a map was constructed, showing the portion of the United States which met the above qualifications. Figure 2 shows this area, plus the areas too dry, too wet, or too hot. The unruled section of the United States lies beyond the poleward limit of growth for the cork oak.

[3] Victor A. Ryan, *Some Geographic and Economic Aspects of the Cork Oak* (Baltimore: Crown Cork & Seal Co., Inc., 1948), p. 19.

DISTRIBUTION OF AMERICAN CORK OAKS

With this picture of climatic and soil factors, our attention can be directed to the introduction and spread of the cork oak in the United States. Thomas Jefferson seems to have been the first American interested in the cork oak, but his attempts at establishing a cork production industry proved futile. The government was successful in 1858 and again in the eighties in having a few trees survive in the southeastern states and California. A substantial planting at Chico, California, was made in 1904, and state and local plantings have resulted in a distribution of cork oaks in the United States as shown in figure 3. It is interesting to note that they are not limited to the area usually classified as typically Mediterranean.

In 1940, over five tons of bark were stripped from California trees, marking the first time that cork oaks outside the Mediterranean region had been stripped of commercially marketable cork. Tests by the Crown Cork and Seal Company of Baltimore showed this bark to be equal

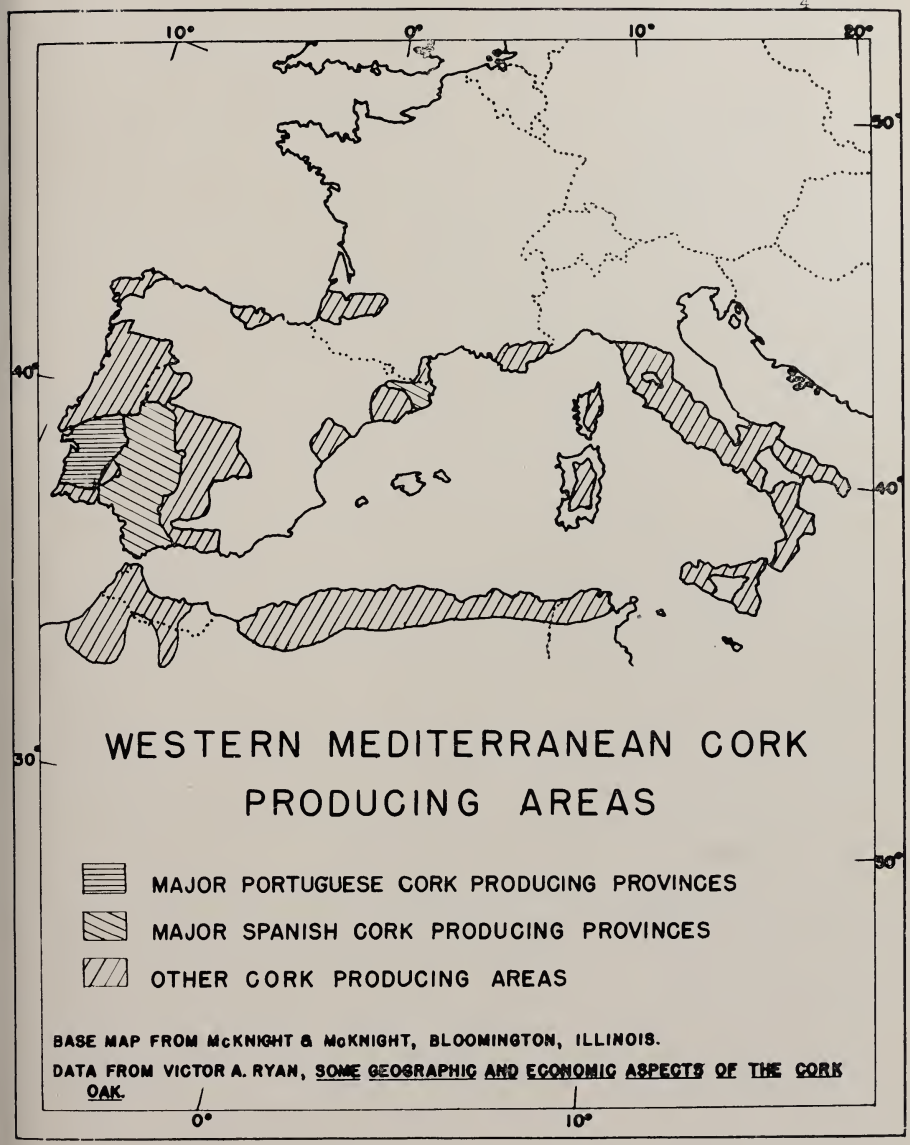
10°
0°
10°
20°
50°
40°
40°
30°
30°
WESTERN MEDITERRANEAN CORK PRODUCING AREAS
MAJOR PORTUGUESE CORK PRODUCING PROVINCES
MAJOR SPANISH CORK PRODUCING PROVINCES
OTHER CORK PRODUCING AREAS
BASE MAP FROM McKNIGHT & McKNIGHT, BLOOMINGTON, ILLINOIS.
DATA FROM VICTOR A. RYAN, SOME GEOGRAPHIC AND ECONOMIC ASPECTS OF THE CORK OAK.
0°
10°

Fig. 1.

in quality to Old World cork. When considering that the United States imports some 150,000 tons of cork annually, it is readily seen that it was the *fact* rather than the *amount* of production that was of chief significance.

Production and Marketing Problems

In order to develop an overview of the industry, we may turn our attention to how the industry is conducted, what marketing practices may be developed, what competition in land use may be encountered, how competition by other products and by foreign countries is met, and what other problems cork producers may face.

Conduct of Industry

Cork production is a forest industry, the commercial product, cork, being the outer layer of the *Quercus suber* and *Quercus suber occidentalis* species of evergreen oak. The inner layer of bark, or phellogen, is alive and acts as a base on which each year the tree adds a new layer of cork. As these succeeding new inner layers are added, the outermost layers cease to be a living part of the tree and serve only as an insulating wrapper protecting the tree against loss of moisture and against the hot winds known as siroccos in the Western Mediterranean region.

It has apparently been known since Greco-Roman times that this outer bark could be removed without injury to the tree. The process of bark removal is known as stripping, and the same methods are being used in the United States that have been successful in Europe and North Africa. Two cuts are made around the tree with a sharp two-bladed hatchet, one cut at the ground level and the other just below the main branches (or at the height prescribed by law in most of the Old World cork-producing countries). Two vertical cuts following natural crevices in the bark are made, joining the horizontal cuts. The wedge-shaped hatchet handle is then inserted under the loosened bark and the whole sheet is pried off. The larger lower branches may be stripped in the same manner. Care must be taken not to injure the inner bark, and stripping should not be undertaken while a hot wind is blowing as the newly exposed phellogen will be dried out too rapidly. Nevertheless, the middle of the summer is the accepted stripping season.

The first stripping produces cork with a rough, grayish, uneven surface, known in the United States as "virgin" cork, suitable only for grinding for cork insulation and cork composition products. The second stripping is considerably better and, with the third stripping, fine quality cork is obtained. The trees are first stripped when 15-20 years of age and every 9-12 years thereafter during the productive life of about 100 years. The stripped bark is piled and allowed to dry a few days in the forest. It is then ready for boiling, a process which softens the cork and increases its elasticity so that it can be flattened for baling. Boiling removes dirt, sap, and tannic acid, and also softens the useless woody outer layer which is scraped off. The cork is dried, roughly sorted according to quality, and baled, ready to be taken from the immediate area of production.

Marketing Practices

American cork production has been so limited and so intimately

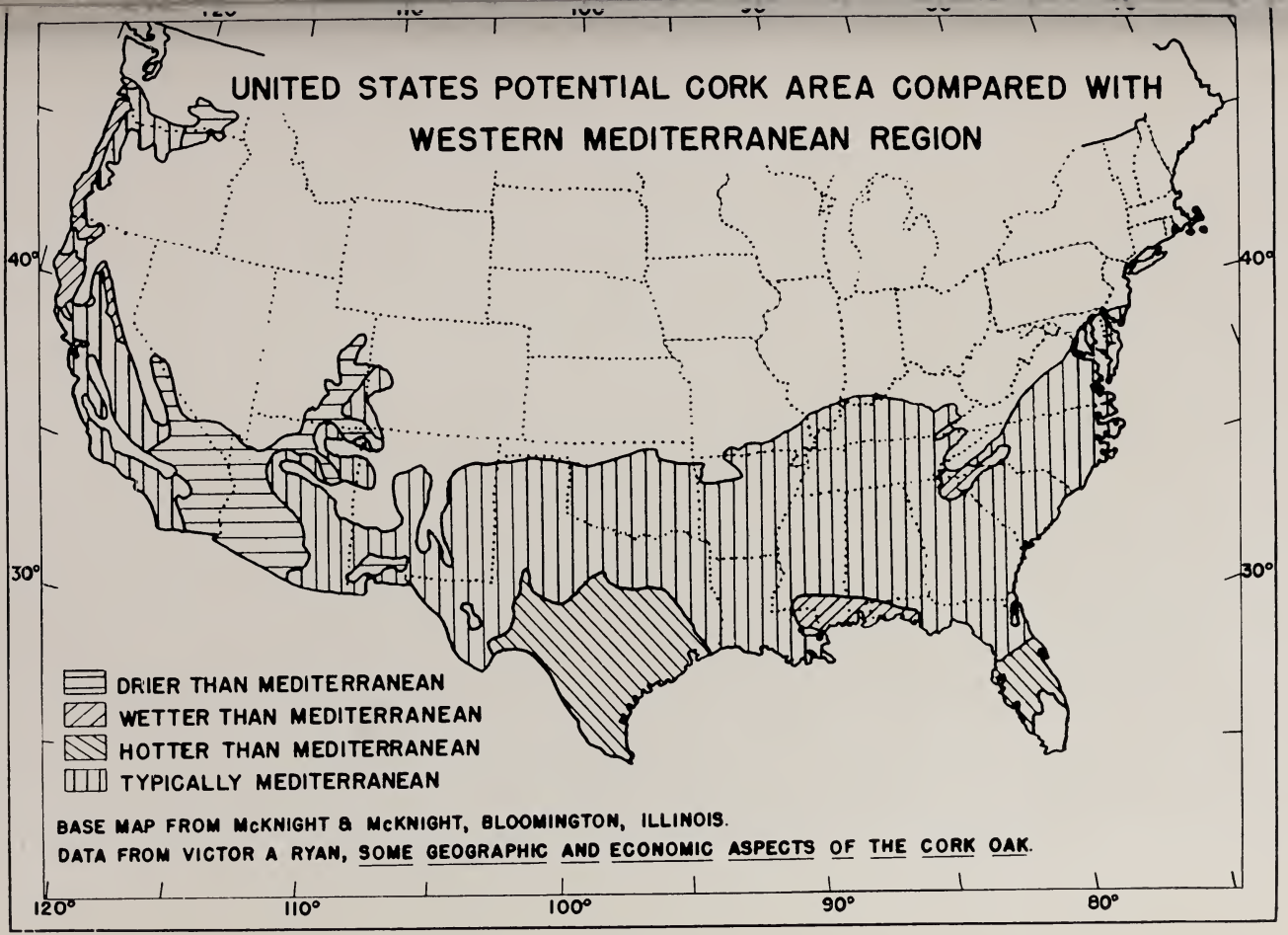
UNITED STATES POTENTIAL CORK AREA COMPARED WITH
WESTERN MEDITERRANEAN REGION
40°
30°
DRIER THAN MEDITERRANEAN
WETTER THAN MEDITERRANEAN
HOTTER THAN MEDITERRANEAN
TYPICALLY MEDITERRANEAN
BASE MAP FROM McKNIGHT & McKNIGHT, BLOOMINGTON, ILLINOIS.
DATA FROM VICTOR A RYAN, SOME GEOGRAPHIC AND ECONOMIC ASPECTS OF THE CORK OAK.
120°
110°
100°
90°
80°

FIG. 2.

connected with the cork manufacturers that a definite code of competitive marketing practices has not as yet been established in the United States. In order to see what may develop here, an examination of two marketing systems employed in the Mediterranean region follows.

By one method the buyer purchases the cork bark in the forest before stripping. Before purchasing, the buyer sends a sampler through the forest who removes a small cylindrical section of cork from representative trees much as a fruit dealer plugs watermelons. These discs are taken to the buyer's office for careful examination before the buyer makes a bid to the forest owner.

The second method involves the sale of the stripped cork bark at public auctions. Some of these sales are handled in a manner similar to American auctions, while others have the unique feature of starting at a high figure, the auctioneer gradually lowering the asking price until a bid is received. The first lots of cork offered are generally small, and are frequently purchased by small operators before the large buyers come in and take everything.[4]

It should be re-emphasized that American cork production has been so limited to this time that neither the above nor other marketing practices have been developed in the United States.

Competition in Land Use

The study of soils revealed that Mediterranean cork was produced on relatively poor soils, the leached subtropical and tropical reds and yellows, and the brown steppe with its alkaline accumulations frequently forming a hardpan layer in the soil. In the United States, desert soils are supporting many mature cork oaks. Thus it is evident that the cork oak will thrive upon soils in which other vegetation is sparse. The United States contains hundreds of thousands of acres of the above mentioned soil types that could be planted to cork oak without crowding out or even infringing upon other economies. Many of the recent plantings in America have been made along fence rows, roadways, and in pasturelands. Few of the cork oak forests in the Mediterranean region are pure stands. The cork trees are often associated with olive trees, vineyards, or with other live oaks in pastures. Swine do very well feeding upon cork and other oak acorns. The pork of acorn-fed swine is said to have a very desirable piquant flavor. These concomitant land uses permit a sizable income per unit of land.

Competing Products

As mentioned in the opening paragraphs, no single acceptable substitute for cork has been found. Some of the materials used in place of cork are just as scarce as cork and are critically needed for other uses, as was found during World War II. Even for packing material, military technicians could find no successful substitute for cork. Materials such as pine needles and dried grasses were tried but none had all the qualities of cork—heat resistance, buoyancy, and strength. Barks of other trees, such as Pao Santo, Douglas fir, and other true firs have been studied and tested, but none has proved entirely satisfactory. To compete with natural cork in normal times, other barks must be cheaper, more readily accessible, or better than cork. At

[4] Arthur L. Faubel, *Cork and the American Cork Industry*, New York: Cork Institute of America, 1941, p. 16.

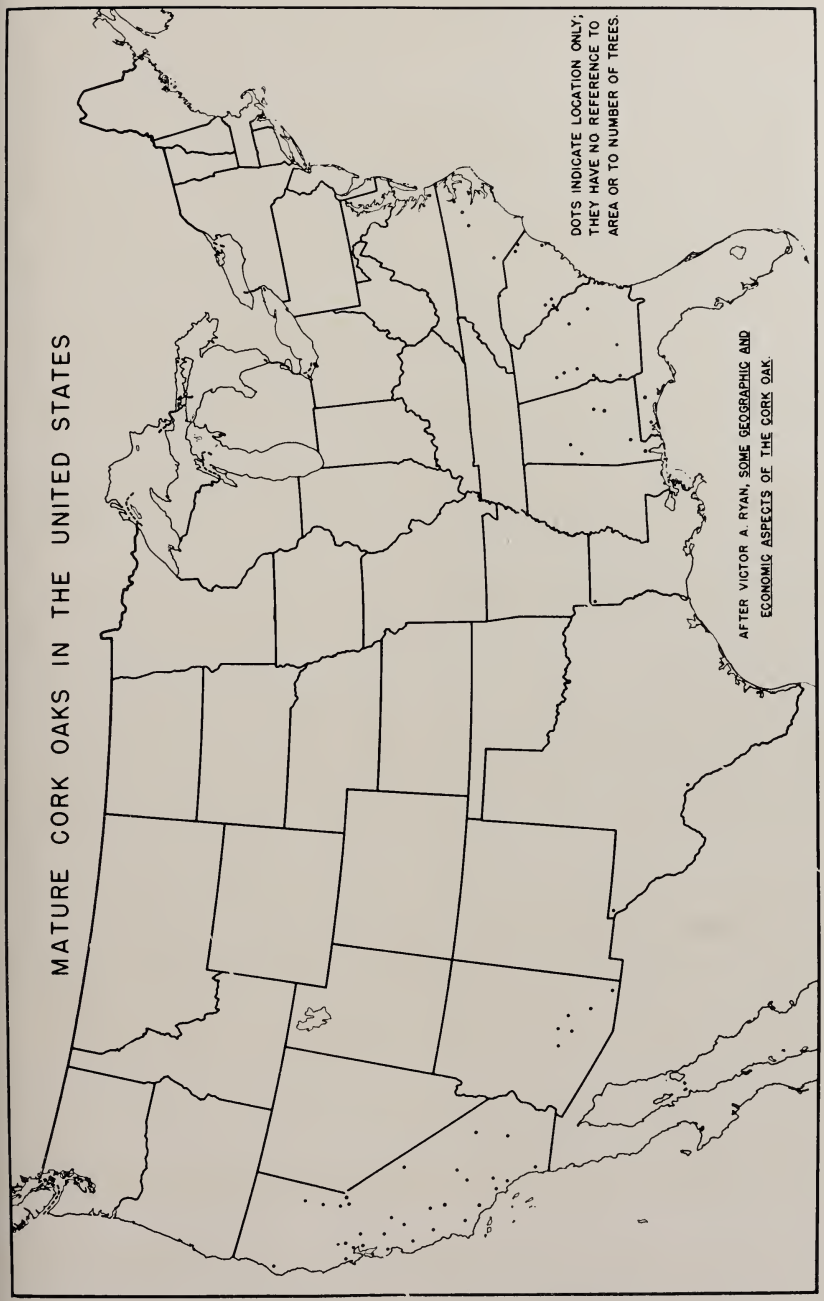
MATURE CORK OAKS IN THE UNITED STATES
DOTS INDICATE LOCATION ONLY; THEY HAVE NO REFERENCE TO AREA OR TO NUMBER OF TREES.
AFTER VICTOR A. RYAN, SOME GEOGRAPHIC AND ECONOMIC ASPECTS OF THE CORK OAK.

FIG. 3.

Table 2.—United States Imports of Unmanufactured Cork[5]
(Thousands of pounds)

Year	M Pounds
1927	223,091
1928	229,671
1929	267,598
1930	174,615
1931	135,401
1932	118,438
1933	187,184
1934	122,565
1935	153,076
1936	216,390
1937	322,898
1938	158,381
1939	227,575
1940	318,336
1944	189,629[a]
1945	265,453[b]

a From *Foreign Commerce and Navigation of the United States. Calendar Year 1944*, Vol. I, *Import and Export Statistics*, p. 199.
b *Ibid. Calendar Year 1945*, p. 133.

present they are none of these. Herman M. Kulman has patented a synthetic substitute made from peanut hulls.[6] It has been tested and judged acceptable for use in bottlecaps, gaskets, and wallboard, but is more expensive than natural cork.

The discussion of the other natural products and the synthetic material indicates that natural cork, to date, has been able to meet the competition of any and all substitute products. This is further borne out by the United States import statistics given in table 2. By 1945, United States imports of natural cork had again risen to a figure exceeded only by three peak pre-war years, indicating that very little, if any, of the United States demand is being filled by substitutes when natural cork is again available in large quantities.

Foreign Competition

Since natural cork apparently can meet successfully the competition of substitute products, the competition faced by American producers will come from cork production abroad. There are at least two ways to meet this competition: one, with the aid of a protective tariff; and, two, by actually equalling or under-bidding the prices of Old World cork at the factory door. At present, unmanufactured cork is on our free trade list, and a protective duty seems unlikely and probably undesirable at this time. Victor A. Ryan's study showed that in terms of income per acre of cork oaks, based on actual American production costs and present Mediterranean prices, the American grower can compete with the Old World producer and deliver bark at the American factory door at a lower figure.[7] It would seem that a scientifically based American cork production industry should easily survive the competition of the Old World cork production industry as the latter is now being conducted.

Other Problems

Other problems that American cork producers must face are cork oak diseases and insect pests. As yet, only the cork oak cynipid has given trouble. This small insect has infested some California trees, killing smaller twigs, and reducing the vitality and bark growth in some instances.[8]

Another problem involves the rate of growth of the cork bark. Although it is known that xerophytes have no definite moisture requirements, being able to tolerate more moisture while continuing to grow slowly, there is some acceleration in the growth rate of cork due to in-

[5] Mary V. Day, "Cork Goes to War," *Foreign Commerce Weekly*, pp. 54, 58.
[6] "Peanut Hull Cork," *Business Week* (November 27, 1943), pp. 54, 58.
[7] Ryan, *op. cit.*, pp. 85-87.
[8] E. O. Essig, "The Cork Oak Cynipid in California," *Journal of Economic Entomology*, XXXVI (February, 1943), pp. 123-124.

creased precipitation. Since more rapid growth creates coarser structure and less valuable cork, the regions of the United States in the potential cork area wetter than the Mediterranean region are at a disadvantage compared to the drier American areas. They will lose more in price per ton of cork due to poorer quality than they will gain in weight by increased growth rates. On the other hand, trees in the wetter areas are larger producers of acorns, so important for planting in the establishment of any future cork production industry. Cultivation of the cork oak may increase the growth rate and imposes a problem as to the extent of cultivation economically desirable.

Conclusions

The United States has had a constant and fairly consistent need for cork, an especially critical essential material in wartime. The United States has within its borders vast areas having climate and soil characteristics similar to the present producing areas in the Mediterranean region; also it has other climatic regions in which cork trees are now growing. United States cork has been found equal in quality to Mediterranean cork. The estimated returns of American cork production conducted scientifically would seem to compare very favorably with Old World cork production income on an annual income per acre basis. A cork production industry in the United States could be established in addition to our present activities, with little or no infringement upon present use of productive lands; and there seem to be no technical problems or difficulties of consequence.

While the above facts may lead one to conclude that the establishment of a sizable cork production industry in the United States is inevitable, further studies will be necessary to test the application of theory to practice, and to interpret the effects that economic and political developments in the world have upon cork production. At this time we can only conclude that the United States seems to have the geographical possibilities for cork production, and reiterate the statement of J. Russell Smith, made in 1929, that "apparently there is no reason except inertia why we should not in time have an extensive cork (production) industry in the United States."[9]

[9] J. Russell Smith, *Tree Crops—A Permanent Agriculture.* (New York: Harcourt, Brace and Co., Inc., 1929), p. 139.

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WATER RESOURCE CONSERVATION IN ILLINOIS

H. E. HUDSON, JR.
State Water Survey, Urbana

In common with the rest of the United States, Illinois has been experiencing growth in population, with resulting greater density of population, larger communities, and increasing opportunities for the affairs of men to infringe on the affairs of other men. Thus the way we treat our resources comes to have an increasingly important effect on men, far greater than was the case a few decades ago.

With this increasing saturation of population has come development of a form of inertia, caused by the increasing growth of investment in business of every kind. A man now has a greater stake in his farm, in his factory, or in whatever enterprise he is engaged in. It takes more capital to start an enterprise, and this leads to higher overhead costs, so that men are much less amenable to changes in their way of doing things. This of course has led to regulation. Inevitably it will lead to increasing regulation in the field of resource development. If history repeats itself, we may expect the increasing regulation to come at times of stress such as periods of war or periods of depression. Thus we must give thought to the needs of the future at times when conditions are "normal."

General Situation

Figure 1 shows the principal sources of water supplies in Illinois. It will be noted that in a large part of southern Illinois, municipal water supplies are secured almost entirely from surface water sources, principally impounding reservoirs. Through the marginal drift area and through the minor rock well area, difficulty is noted in securing sufficient groundwater for municipal or industrial use.

There are exceptions to the above generalizations, where porous gravel deposits occur along streams or in buried bedrock valleys in these areas.

In general, groundwater levels throughout Illinois have not been seriously affected by works of man. In certain locations, there have been minor effects caused by drainage activities, by dredging channels, and to some extent by the increased cultivation of the land. A century ago, when little of Illinois was under cultivation and most of the soil was in prairie grasses, infiltration rates were high, and rates of penetration of rainfall into the earth were rapid.

With the changing trend of use of land to cultivated crops such as corn and soybeans, infiltration rates have been reduced. There has probably been some lowering of water tables owing to this change in land use, but no data are now available to measure the amount of the effect. The influence is probably relatively minor compared to the effects that are occurring in areas of large population, where heavy groundwater developments have taken place.

Groundwater

The occurrence of groundwater is determined by measuring water levels

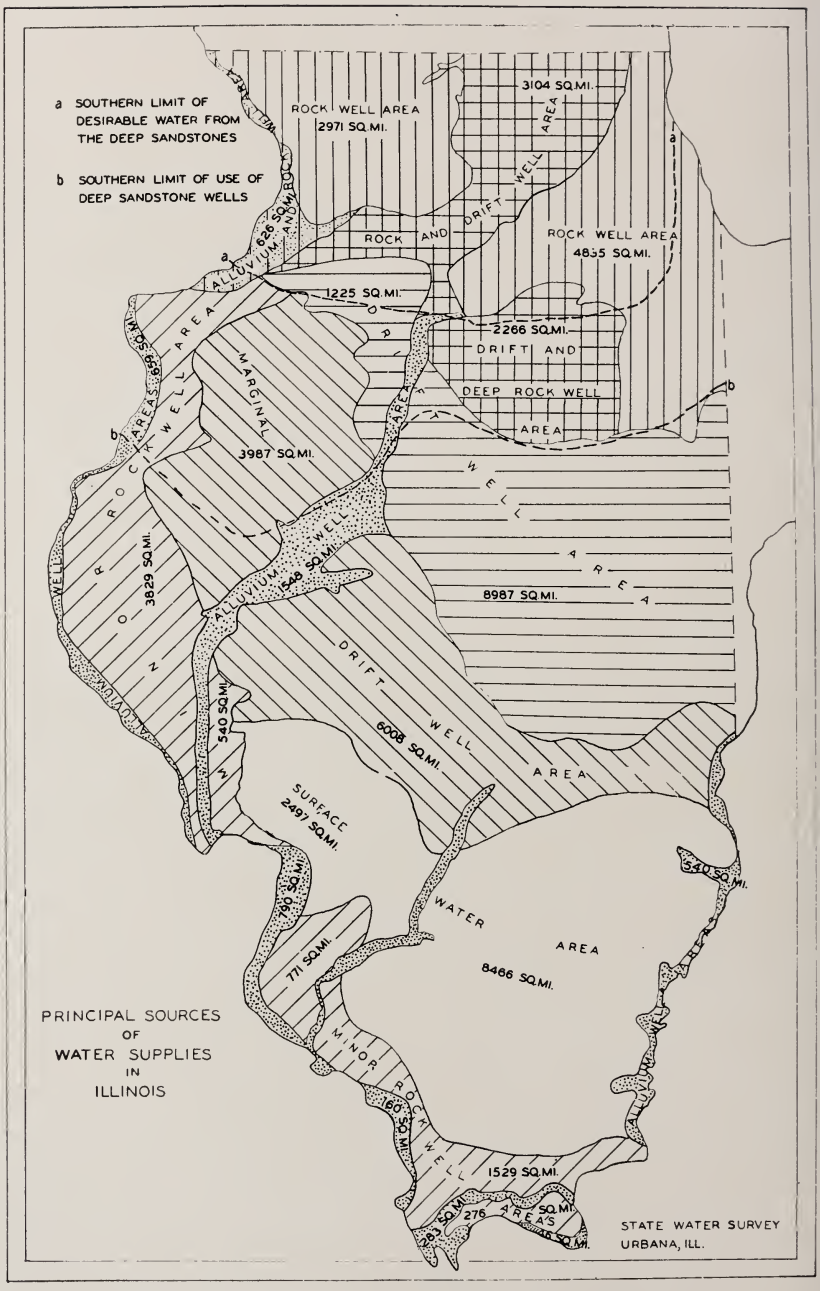

Fig. 1.—Principal sources of water supplies in Illinois.

in wells, by making pumping tests to observe the movement of those water levels, and by special chemical techniques to measure the movement of the waters and to identify their sources.

Recharge of groundwater from precipitation is a very slow business. With a comparatively few exceptions, it takes at best many months, and sometimes requires centuries. As Dr. Buswell, Chief of the Water Survey, has remarked, in some locations our best solution is to have prayed for rain 5,000 years ago. Groundwater data indicate that, over about four-fifths of the state, water can be secured in some quantity, but there are limits to the amounts that can be obtained at any given location.

Throughout northern Illinois it is possible to secure water in large quantities from wells drilled deep into the bedrock. In the east central part of Illinois, comparatively large volumes can be secured from wells drilled in the glacial drift. At many locations in the state there are limited deposits of sand and gravel that can yield sizable quantities of water, but these are difficult to locate and evaluate, requiring careful engineering study in each separate case.

For the most part our groundwater resources are healthy, unaffected by human activity. But at places where large concentrations of population have relied on groundwater, symptoms of trouble are appearing. These local problems have led many to suspect that groundwater resources over the whole state were failing. It is true that there have been difficulties at Chicago, Joliet, Rock Island, Peoria, East St. Louis, and Champaign-Urbana. Some of these local situations have become quite acute, most noticeable being that at Chicago, where water levels in deep wells are now as much as 500 feet lower than they once were. The lowering of water levels in heavily pumped areas affects less than five percent of the area of Illinois and, from the point of view of depletion of total water resources available in the state, it is not of great importance. Outside these areas of receding water levels there are large quantities of groundwater available which can be developed, although the costs of these new sources will be greater than the cost of the present groundwater development.

More than half the total population of Illinois is housed in the small portion of the state in which groundwater levels have been lowered by heavy extraction. These groundwater recessions therefore are of major importance to a large and vital section of Illinois' economy. The fact that the groundwater difficulties are limited in areal extent must not be allowed to obscure the influence of these effects on a major portion of the state's population.

Table 1.—Industrial Use of Groundwater

Metropolitan area	Total use Mil. Gal./Day	Per capita use Gal./Day
Los Angeles, Calif..	360	124
Long Island, N. Y..	280	61
Houston, Texas...	170	333
Memphis, Tenn....	105	316
San Antonio, Texas	100	313
E. St. Louis, Ill....	89	736
Peoria, Ill.....	85	680
Philadelphia, Pa.–Camden, N. J.....	85	29
Dayton, Ohio.....	85	313
Chicago, Ill.....	84	21

Table 1 shows a summary of groundwater use in the 10 largest areas of industrial groundwater de-

velopment in the United States. It is interesting to note that three of these areas are located in Illinois: Chicago, Peoria, and East St. Louis. It is even more interesting to note that, of the 10 largest industrial groundwater developments (probably the largest 10 in the world), the two most intensive developments, when considered on a basis of the amount of water taken per person per day are East St. Louis and Peoria. Water is a major factor in industrial development, and it has been an extremely important factor in the growth of the state.

Surface Water

The rain that falls in the state and some that falls in our neighbor states, Indiana and Wisconsin, can travel three paths. It can evaporate; about two-thirds of it does. It can run off into streams; about one-third of it does. It could soak down into the earth to become part of our groundwater supply. Our best arithmetic indicates that only a very tiny fraction gets into the groundwater supply.

We measure the amount of surface water that occurs in Illinois through stream gaging installations operated by the U. S. Geological Survey office in Champaign. Another important part of the surface water study is the measuring of water quality, done by chemical analyses carried on in our laboratories.

Streams dry up at times and cannot be relied on to produce a dependable constant yield. Man therefore resorts to construction of impounding reservoirs to store water for the dry periods. Illinois has available approximately 600 useful reservoir sites. We have about 500 lakes and reservoirs. You can see that we have used a substantial proportion of the sites available; it is therefore of great importance that we use wisely those that remain. In the past, reservoirs have been constructed without full regard to soil and water relationships. Recent surveys indicate disturbing silting rates. We have come to realize that the conservation of soil is an essential to preservation of surface water resources. Unless we can succeed in keeping the topsoil on our farms, our society will come to an abrupt realization that the farms are no longer valuable, and the reservoir sites are full of sediment. Present data indicate that this may become a real problem during our children's lifetime.

If we are thrifty with our surface water resources, safeguarding them against silting and polluting, Illinois will have enough supply to support a population 10 times as great as it now has without re-use of water. Re-use techniques, using the water after self-purification in streams or after special chemical purification, would let Illinois support a population many times greater yet.

Our surface water resources are adequate for any foreseeable needs of the state, but they can seriously deteriorate if we fail to husband them.

Soil-Water Relationships

The principal source of turbidity in most rivers is the erosion of soil from the land. This is clearly illustrated by considering the Illinois River Valley. It is calculated that the total amount of suspended material which would be discharged into Illinois River by populations which use it as a place of waste disposal would amount to approximately 75,000 tons per year if sewage were untreated. This would average about

Fig. 2.—Soil particles leaving the cultivated field.

Fig. 3.—Sediment deposit along a small stream in Illinois.

8 to 10 parts per million. Modern sewage treatment methods could reduce this by about 90 percent: the total suspended solids discharged into the river from treatment plants thus averages about one part per million.

In comparison, the amount of silt which reaches the river from eroding agricultural land is estimated at 6 million tons annually or 418 parts per million. The problem of clarifying the Illinois River is therefore to a large extent an agricultural problem, although it is also a pollutional problem. The soil particles which discolor the Illinois River originate on the cultivated farmland of the drainage basin, as illustrated in figure 2. The answer to the problem lies in the establishment of practices and farming methods that will reduce the loss of soil from farms. Establishing these practices is a slow job, but the County Soil Conservation Districts are at work on it.

Source of Soil Pollution in Illinois

Most people think of erosion as a phenomenon that occurs primarily on steep lands, frequently taking the form of gully erosion. State Water Survey studies indicate that the bulk of the sediment does not come from steep land. Most of the sediment reaching Illinois streams comes from sheet erosion of comparatively level or gently sloping lands, lands which are being used for production of intertilled crops (corn and soybeans). Difficulty arises due to the fact that the land is kept bare by continual tillage so that it is more readily erodible. The absence of a protective cover of vegetation intensifies the action of splash-erosion by raindrops. From the farms the silt finds its way through drainage ditches and small streams into the major tributaries and thence into the main river. Along each of the small streams and major tributaries, some of the sediment is deposited. Figure 3 shows a sediment deposit along the course of a small intermittent stream. A substantial proportion of the silt, however, still reaches the main river.

A century ago the Illinois River valley was an area largely devoted to prairie and timber. An analysis of the soil survey maps indicates

that of the total area of the Illinois valley in Illinois, 21 percent was originally timberland, 61 percent was prairie, and 18 percent was terrace and bottomland soils.

The Illinois program of sedimentation study is built around work by the State Water Survey in measuring the actual amount of sediment accumulated in reservoirs, and in compiling the hydrologic and engineering facts relative to each of the reservoirs. The lake owners provide records of construction, modifications and use, and labor to aid in the actual surveys. The Office of Research, Soil Conservation Service, contributes technical advice and guidance and furnishes some of the equipment for the work.

Cooperating in the studies, the Soil Conservation Districts within the counties, which are operated by local farmers, collect data on the erosion on the land. The data include complete or sample surveys of conditions on the watershed for each reservoir surveyed, such as location of eroding areas, extent and degree of erosion, slopes of land, and soil groups involved in the erosion process. The Agricultural Experiment Station of the University of Illinois analyzes samples of sediment taken during the engineering survey of the lake to determine the source of the sediment. The Experiment Station also summarizes the conservation survey data furnished by the local districts and directs the analysis of the survey so that the points of most serious erosion may be determined.

Figure 4 shows a sediment deposit in a public water supply reservoir on the Illinois River basin.

Under this cooperative program, the Water Survey has been involved

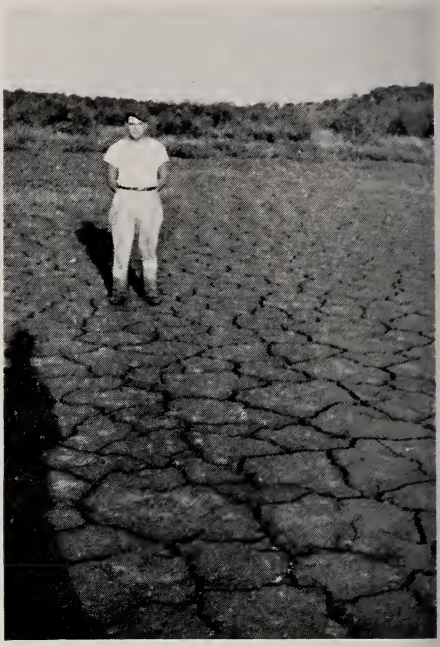

Fig. 4.—Deposit of silt in an Illinois reservoir.

in the surveying of 14 reservoirs, eight of which are located in the Illinois valley. (See fig. 5.) In choosing a site for survey work it is necessary to give consideration to kinds of soils involved in the watershed, as determined from basic data furnished by the State Soil Survey, and on many other factors, such as the rainfall, the topography of the land, and the farming practices in the area of study.

The results of the Illinois surveys are summarized in figure 6. The amount of silt that arrives in reservoirs is shown as the vertical axis, and the size of the contributing watershed is shown as the horizontal axis. From this graph it is seen that the contribution of silt into reservoirs from small watersheds is greater per square mile than the amount of silt that arrives in reservoirs which receive the flow from large

watersheds. This occurs because a portion of the sediment drops out of the flow of water enroute from the point of erosion to the reservoir. There is a substantial loss of sediment on small watercourses along the way (fig. 3).

Figure 6 does not indicate that erosion is worse in small watersheds than in large ones, but rather that less sediment per square mile arrives in the large reservoirs than in the small ones. The average annual rate of sediment production on the smallest watershed studies is in the neighborhood of 3 acre feet per square mile, which checks reasonably well with a mean figure of 7 tons of sediment per acre, estimated by studies on the land.

Silting Rate of Illinois River

An analysis of the data shown in figure 5 makes it possible to estimate what is happening in the Illinois Valley. Using existing reservoir survey data, the amount of sediment

Fig. 5.—Reservoir sedimentation surveys in Illinois, April 1, 1950.

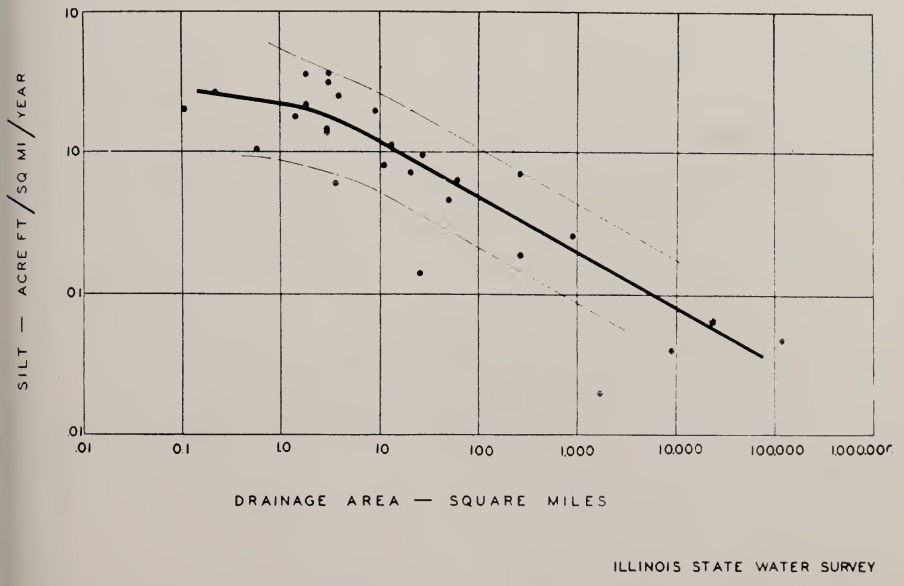

Fig. 6.—Sediment production rates in Illinois.

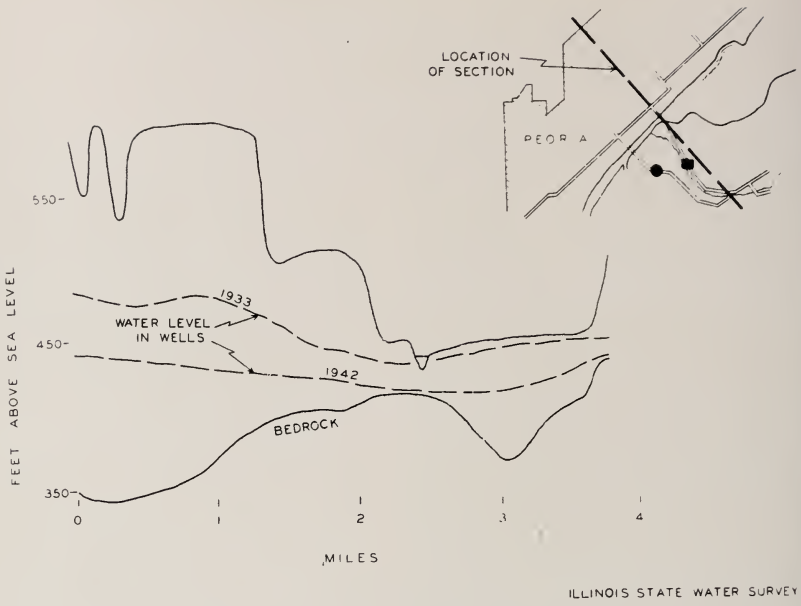

Fig. 7.—Groundwater cross-section at Peoria.

reaching the Illinois has been estimated, together with the amount of sediment that passes on out of the Illinois. We find that the total erosion in the Illinois valley is probably in the neighborhood of 68 thousand acre feet per year. The amount of this sediment which reaches the Illinois River is of the order of 4,000 acre feet per year. The amount which is discharged at the mouth of the Illinois is approximately 1,500 acre feet of sediment per year, leaving about 2,400 acre feet of sediment deposited along the Illinois valley. If we estimate the length of the Illinois as 295 miles, and the mean available flood plain of the valley as 4,640 feet wide, we find that enough sediment deposits to cause the valley floor to rise at the rate of about one foot in 70 years. The rate of sedimentation in the channel proper is probably considerably higher.

Figure 7 shows the situation which has developed at Peoria. The figure depicts a cross-section through the city of Peoria taken as shown in the heavy dashed line in the upper righthand portion. It is a cross-section at right angles to the river at the bottom of the Peoria lake, at the beginning of Peoria Narrows. In this cross-section it may be seen that groundwater levels in 1933 were generally higher than those in the river. The heavy industrial use which has grown in the last few decades at Peoria has resulted in a lowering of groundwater levels to the point where, in much of the Peoria region, groundwater levels are now far below the level of the water in the river. In most situations it is expected that the creation of such a situation will lead to discharge of water from the river into the ground. Water Survey studies indicate that this happens to a very

small extent at the locations shown, so that the groundwater deposits in the Peoria region must depend primarily on water entering them from other sources than the Illinois River (1). Thus the presence of sediments in the river exert a marked adverse effect on the availability of groundwater for industrial use.

Summary

There is an extraordinary relationship between soil and water resources which is not given adequate consideration. It is a complex relationship, but the basic facts are known and can be applied in the interest of conservation of surface water.

Over-development of groundwater resources is taking place at a few areas in Illinois. Eventually the cost of pumping the water from progressively greater depths may be a stronger controlling factor than any legal conservation measures. In the Chicago area this may mean a greater demand on Lake Michigan, where from the engineering point of view a considerably larger withdrawal could be made.

There are solutions for every water shortage occurring in Illinois. It is our responsibility to spotlight the facts on water resource availability and use. As the activities of men cause increasing interferences in the use of water resources, and regulation comes to be advocated, these facts will become the basis for deciding what is to be done.

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(1) "Groundwater in the Peoria Region," Illinois State Water Survey Division Bulletin 39, 1950.

SLOPE STUDIES OF NORTHERN ILLINOIS

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In recent years considerable interest has arisen in the quantitative expression of differences and similarities of terrain from region to region.[1] However, most of these studies have been primarily concerned with a technique or method of analysis and representation, and have generally been exemplified by a single area. The applicability of these methods to various types of terrain and a comparison of results obtained from different landform regions has been largely, though not entirely, neglected. Moreover, none of the papers has presented any appraisal of the results of such investigations in terms of the results or, more especially, of the results as evaluated in terms of the number of data required and the time involved in their analysis. This paper reports results from the utilization of only two techniques, neither of them new.

Relative Relief

The first method is one introduced by Guy-Harold Smith in a map of "The Relative Relief of Ohio."[2] The method of calculation is simple. From topographic maps of an area the difference between the highest and lowest point in each five-minute rectangle is ascertained. These values are then entered on the manuscript map and isolines are drawn connecting the center of all rectangles having the same values.

Two areas in the United States have been mapped using this method —the state of Ohio by Smith[3] and the Driftless Area of Minnesota, Wisconsin, Iowa, and Illinois by Smith and Trewartha.[4] The Driftless Area contains areas of low relief on its margins, and Smith and Trewartha, by shading heavily the critical relief range were able to show strikingly that the borders of the Driftless Area coincided remarkably well with a particular local relief range. Western and northwestern Ohio have very considerable areas of moderate or slight relief and these, of course, were represented on Smith's map of the state. However, in both of these areas sections of low relief made up only a small part of the total area.

The principal objective in applying the method to northern Illinois was to determine from a comparative study of the various relative relief maps produced and the topographic maps of northern Illinois what results could be obtained in the representation of smaller differences in local relief in an area of predominately low relief.

Figure 1 shows the local relief of northern Illinois using the method developed by Smith and using the same relief value limits. Five conclusions can be reached almost im-

[1] A large number of these studies are summarized and discussed in: Louis A. Wolfanger, *Landform Types,* Mich. Agric. Exp. Sta. Tech. Bull. 175, East Lansing, Mich.

[2] Guy-Harold Smith, "The Relative Relief of Ohio," *Geog. Rev.,* Vol. 25, 1935, pp. 272-284.

[3] *Ibid.*

[4] G. T. Trewartha and G.-H. Smith, "Surface Configuration of the Driftless Cuestaform Hill Land," *Annals Assoc. of Amer. Geographers,* Vol. 31, 1941, pp. 25-45.

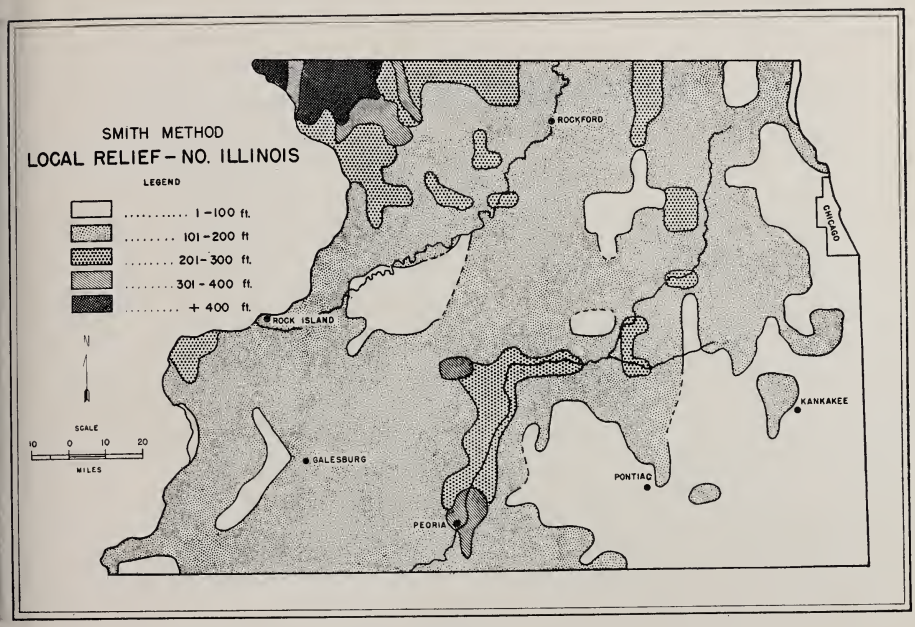

Fig. 1.

mediately from the most cursory inspection of the map: (1) the overwhelming preponderance of the land in northern Illinois has less than 200 feet of local relief; (2) the glacial lake plain of Chicago, much of the Kankakee River drainage way, and the Grand Prairie area have very low relief—less than 100 feet; (3) the only section of northern Illinois having strong relief is the Driftless Area in the extreme northwest corner of the state; (4) lands immediately adjacent to the Middle Illinois Valley have moderate local relief, and (5) the outwash plain south of the Rock River in the Prophetstown area and eastward is an area of low relief.

Very little else of value can be ascertained. The tongue of moderate relief (201-300 feet) extending southward from the northern border west of Rockford undoubtedly reflects the influence of the Marengo moraine but it is wider than the moraine and bears little relationship to its form. The compact area west of the Fox River occupies part of the morainic knot in central Kane County but it bears no significant relationship in either shape or size to the terrain situation in the area viewed either in the field or on topographic maps. The greatest relief in the southern part of the map occurs where the Bloomington moraine crosses the Illinois River valley. Other minor features have even less significance.

In calculating local relief from contour maps having a 20-foot contour interval it is obvious that there will be more rectangles having values that are multiples of 20 than are multiples of 10 only. In the construction of any isopleth map it is better to use value limits that have a low frequency than limits having a high frequency of occurrence. Another map was constructed using 90 feet and 190 feet as the value limits

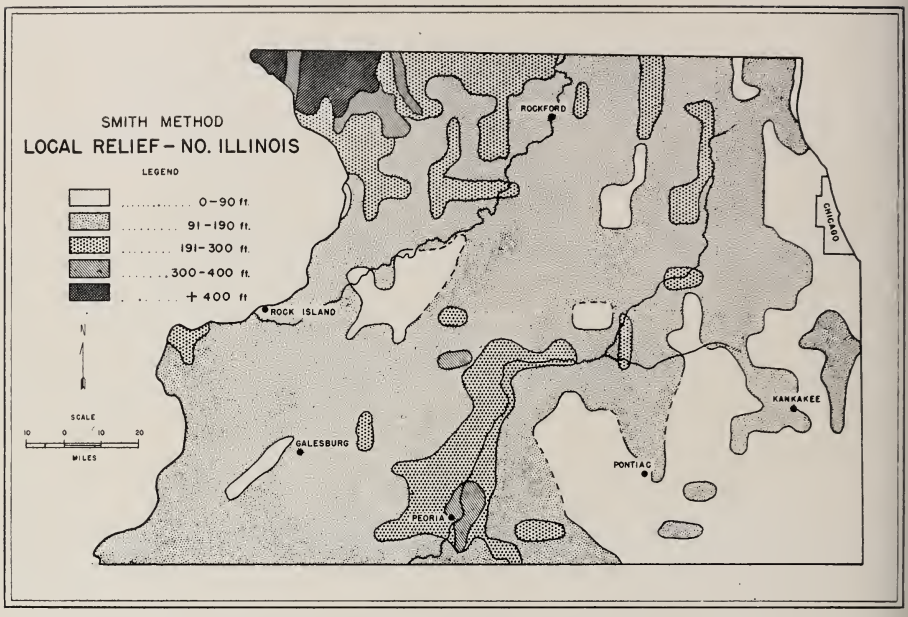

Fig. 2.

instead of 100 and 200 feet (fig.2). All the major generalizations apparent on the first map are equally apparent on figure 2, but the borders of the major areas and the shapes and sizes of many of the minor areas are quite different. Some of the new outlines of these minor areas seem to be more meaningful in terms of portraying actual terrain conditions; about an equal number appear less so.

Once the local relief values have been entered on the base map any number of relative relief maps can be constructed on overlays using any relief value limits that are desired. Several other local relief maps using various relief value limits were constructed. Several of them had much lower value ranges. On all the maps the main outlines of local relief conditions in northern Illinois were clear; on none of them, in the author's opinion, were minor features any more satisfactorily portrayed than on the maps illustrated.

Smith and Trewartha have suggested that experimentation be made to discover a particular size rectangle that will portray conditions more satisfactorily in any particular region than would either a larger or smaller rectangle. The author carried on no experiments of this kind, because of his conviction that whatever was gained in the portrayal of local areas by varying the size of the rectangle would be more than offset by the greatly added difficulties to inter-regional c o m p a r i s o n that would certainly result from using a variety of different sized rectangles from region to region.

Average Slope Conditions

An isarithmic map of average slope can be constructed for an area in a manner similar to that of a map for relative relief except that values

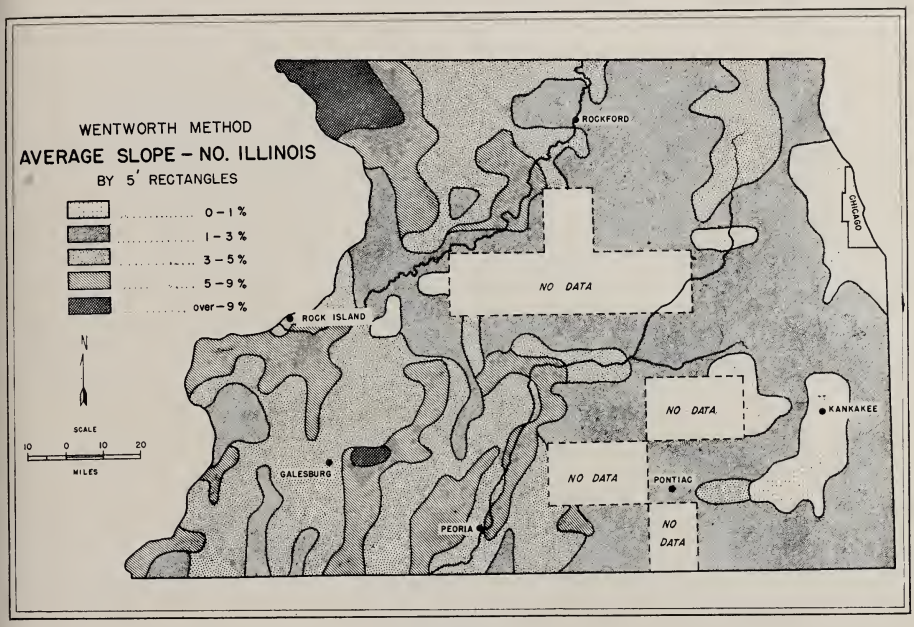

Fig. 3.

for average slope of a 5-minute rectangle as calculated by a method promulgated by Wentworth[5] are used instead of local relief. It must be kept clearly in mind, however, that the two concepts are not the same. It is possible for an area to have strong local relief and comparatively low-angle slopes, or conversely for an area to have low local relief and high-angle slopes.

Figure 3 shows a map of northern Illinois constructed by this method. No sharp general conclusions are immediately apparent. The Chicago lake plain shows up as an area of very low slopes as does a small section around and south of Kankakee. The extreme northwestern area is the only large division having steep slopes. In a very general way it may be noted that the areas flanking the three major rivers of northern Illinois—the Rock, Mississippi, and Illinois—have somewhat steeper slopes than the areas farther removed from these valleys. But with the exceptions just noted, the pattern appears to bear no significant, visible relationship to actual slope conditions in the area portrayed.

In the average slope maps, however, a somewhat better map may be produced by using other slope value limits. In figure 4 the Chicago lake plain is much more satisfactorily delimited and the southeastern corner of the map stands as a clear-cut single area having universally low-angle slopes. Moreover, the morainic belt circling the south end of Lake Michigan stands out quite clearly from the flanking areas of smoother terrain. There is a much stronger suggestion of the smooth outwash plain south of the lower Rock River. Elsewhere on the map the representation seems no better or no worse than that in figure 3.

[5] C. K. Wentworth, "A Simplified Method of Determining the Average Slope of Land Surfaces," *Amer. Jour. of Science,* Series 5, Vol. 20, 1930, pp. 184-194.

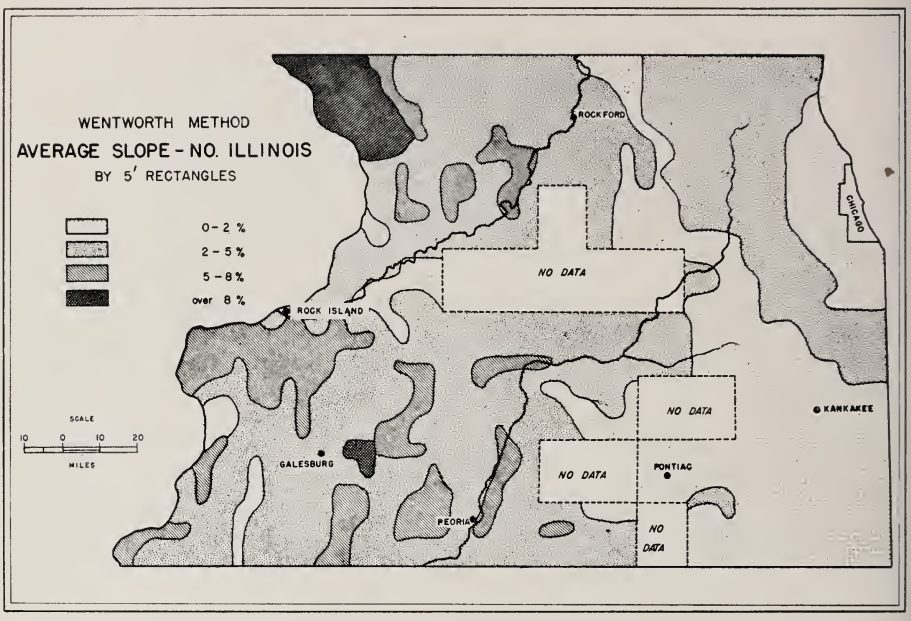

Fig. 4.

Evaluation of Results

The local relief method of expressing quantitative differences in terrain appears to be a useful and practical method when applied to areas of considerable size. Regardless of the relief value intervals used, major differences in local relief stand out clearly. Smaller details of the resultant patterns are ordinarily almost meaningless. The method appears best adapted to small scale maps.[6] The method has two further advantages from the standpoint of practicability. First, the work can be done rapidly. This is especially true if the relief value limits are determined in advance. A rapid inspection of each rectangle will indicate whether or not the maximum relief figure will fall near a value limit. If it does not, then it is unnecessary to determine precisely the absolute extreme values. It should be kept in mind, however, that if the relief of each rectangle is expressed only in terms of a value range it will be impossible to make more than one map from that set of data. Secondly, less reliable data will give satisfactory results. This is especially important in areas where the topographic maps are old, on small scales, and have large contour intervals.

The method of average slope depiction appears much less useful. Calculations using this method are much more time consuming. Even with practice it is not possible to count an average of more than two sheets per hour. Moreover, if the work is done steadily for more than an hour it becomes a great strain on one's vision.

If the results were highly satisfactory they might well be worth the laborious procedure necessary to obtain them. But in an area such as

[6] In many cases small local details, resulting largely from statistical accident, might best be omitted.

northern Illinois this does not appear to be true. The concept of average slope is meaningful only insofar as the majority of the slopes in an area have some approximation to the average slope. In very large sections of northern Illinois, flat interstream areas are interspersed with steep slopes along the narrow valley sides. The resultant average slope figure is nothing more than a meaningless statistical average which merely conceals the facts of actual slope conditions in such an area.

Finally, reliable topographic maps are necessary for calculations of average slope. Since reliable and detailed data are necessary for the construction of such maps, it appears to the author that if such data are available some better method of expressing slope conditions in an area can be devised. Experiments on the problem are proceeding at present.

GEOLOGY

STUDENT PROJECTS AND THEIR PLACE IN GEOLOGIC EDUCATION

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The suggestion has been offered that it would be appropriate at this meeting to make some remarks concerning the work in geology at Augustana College. Back of this suggestion was the thought that most geologists present are university men, who may not have much familiarity with what goes on in the little world which is the one-man or two-man geology department of a liberal arts college. Also, a glimpse into the activities of one such department might be of some interest to the geology teachers from sister colleges.

I must forego any historical introduction, other than to note that at this college geology has been taught for almost three-quarters of a century. The pioneer teachers, Josua J. H. Lindahl and his student and successor, Johan A. Udden, were exceptional men who placed scientific instruction on a basis that was both s o u n d a n d broad — broad enough to include geology almost from the beginning.

Twenty years ago a full major in geology was introduced in the curriculum, so that this science was placed on the same basis as the related disciplines of chemistry, physics, biology, and mathematics. Augustana was the first Lutheran college in the country to take this step —several have since followed its example—and it did so because the men who were then the academic leaders of the institution believed that the cultural value of geology justified such increased emphasis.

Full departmental status involved new, advanced courses, which in turn necessitated additional equipment and supplies. A modest initial budget sufficed for purchase of study collections, maps, and a few essential instruments, but much else seemed necessary for a well-equipped department. With reference to such needs, t h e Physics Department seemed to have a good working solution: what one can't buy, *build*. There remained the problem, to be sure, of how an instructor was to do this with a schedule which regularly included four or five different courses.

In the new department, a solution early presented itself with the assignment of an undergraduate student assistant to the department. This assistant, R. W. Edmund, had the traditional farmer boy's resourcefulness and capacity for work, and given free reign to go ahead on his own had presently equipped the department with useful wall charts, structural models, relief maps, models illustrating construction of topographic maps, and other teaching materials which are still giving good service—not to forget his *opus magnus,* a working geyser model which could be operated before the class, and which no student could ever forget because it erupted with such startling abruptness, the first

spurt of water always hitting the ceiling.

When Edmund graduated—happily to return fifteen years later—the principle of student collaboration in our work had become pretty firmly established. I say "our" because I am speaking also for the several geology teachers who at various times have been on the staff: Leland Horberg, Chester Johnson, Troy Péwé, Barbara Hender Morris, and Rudolph Edmund. However, this principle—if it may be dignified with so formal a term—was long in operation before it was recognized and its possibilities consciously developed. For only gradually was it realized that in almost every geology class there are students who become so interested in the problems of their course that they will welcome an opportunity to do volunteer outside work in it. By encouraging such spontaneous interest wherever it appeared, and by directing it into specific, constructive channels, eventually a situation developed in which much of the work in the department was in the hands of the students, and this has continued to be the case.

How this has worked out may be made clear by some illustrations. Eugene Wittlake, intrigued by the dramatic sweep of Cenozoic mammalian development, undertook preparation of a display depicting the evolution of the horse. This display proved so useful that Lorenz Peterson undertook a parallel project for a representative invertebrate group: the evolution of the Cephalopods. Keith Hussey, becoming involved in the Daemonelix problem, drove out to western Nebraska, studied these curious fossils in the field, and collected a good specimen which he hauled back to the college, there preparing the museum mount which still stands as a record of his undergraduate enthusiasm. Vernon Swanson constructed a geological column showing the formations penetrated by a deep well two blocks west of the campus; this column, mounted just inside the door of the museum, has been useful in many ways. Barbara Hender Morris classified the Mazon Creek collection built up during many years of annual field trips to that locality. Students with a flare for writing, like Jean Soady, have issued Departmental News Letters. Others, especially interested in museum work, like Donna Builte, have aided with making labels, numbering and cataloging, and arranging displays. Still others have assumed responsibility for programs of geological films, presented to the general student body. Wendell Swanson has just constructed some display cases which we badly needed but could not purchase. This year Richard Edmund, Donald Danz, and John Rakus have been engaged in constructing a stream table, now well on the way to completion. Dick Fetzner and Kenneth Larson have been busy with a geyser model to replace the now legendary one built by Edmund years ago. Recent purchase of a rock saw and polishing equipment have opened up a variety of new possibilities.

Not all these projects can be displayed, but we hope that some of our visitors, despite their crowded schedule, may find it possible to visit the Geology Museum in Wallberg Hall, which houses many exhibits, most of them relating to vertebrate paleontology. There you will see two large ichthyosaurs, salvaged as fragments from an eastern warehouse which burned to the ground, which were reassembled by Charles G. Johnson till almost as good as

new. Joseph Hoare found preparing fossils even more absorbing than varsity sports or the college choir, and his brother Richard now continues his long-range project of mounting dinosaur bones. Ansel Gooding, an amateur archeologist, turned his hand to repairing fossils instead of pottery, and completed a number of jobs of high professional quality, including the fine *Pteranodon* skeleton on the north wall of the museum. Three years of tedious but intriguing work by five different students were required to complete the mounting of the mosasaur skeleton which Mr. C. B. Campbell made available to the Museum.

Projects like these have been undertaken in various ways: some purely as an expression of interest, and for the satisfaction of doing them; several as official, recurrent projects of the Geology Club; others, which involved actual research or much delving in the technical literature, as seminars, for which students have received one or two senior college credits; and still others as projects undertaken by student assistants, who receive nominal recompense for at least part of their time.

It seems to us that student participation in extracurricular activities such as these has been all for the good. The impulse, whatever its nature, which launches a student on a project almost always develops into deep interest, and I suspect that long after he has forgotten many a classroom discussion he retains a vivid recollection of what he learned through his individual work. Some students have discovered or developed special skills which later have proved useful in graduate school, or in their own professional work. And quite understandably, students derive lasting satisfaction from having made a significant, worthwhile contribution of some kind to the work of the department.

It is to be expected that through deepened interest, developed in this way, some students might be led to choose geology as a major or even as a career. To some extent this has probably been true, but in encouraging student projects our purpose has always been to help the student grow into a fuller appreciation of the subject matter of geology. We have had, if anything, a special interest in the student who, while preparing himself for music, economics, or some other non-scientific field, has become sufficiently interested in geology to undertake volunteer work in it. The biology major who prepared our fossil horse material undoubtedly became a better biologist for his venture into paleontology; and the pre-seminary student who, through several years, made a hobby of working up vertebrate fossils, is probably a better clergyman for this enlightening, if somewhat unorthodox, experience.

To the institution, the advantages of student projects are quite self-evident. A brief tour of the department will suggest how it has been enriched by illustrative material most of which could not otherwise have been provided, even if funds had been available.

Also, through student assistance the instructors have been relieved of many time-consuming duties, and so freed to devote their best energies to actual instruction. Thus it has become possible for them to teach almost all laboratory sections themselves, rather than to delegate them to assistants.

Most important, perhaps, has been development of, or at least approach

to, a situation in which teachers and class members become closely associated as fellow students, engaged in a common pursuit. This relationship is as desirable in the undergraduate work which is the province of the liberal arts college as it is in the higher levels of the graduate school. And among intangible values such as these one would certainly include the vital personal interest and loyalty which students develop when they are allowed to become collaborators in the work of the department—attitudes which are not likely to end with graduation.

It is worth remarking that the Geology Museum, which thus has been developed mainly by the students, has extended its influence beyond the campus. Not only are there daily individual visitors, here from off-campus, but the Museum is now in regular use by the science classes and clubs of the public schools of Rock Island and nearby cities, and also by many other organizations such as boy scout and girl scout troops, Y. M. C. A. classes, amateur science clubs, and church organizations. So far as possible, instructors or advanced students meet these groups, speak to them, and answer questions; and in many cases when groups in the community request talks on geology they are invited to come to the Museum, where they can be shown the actual documents which the geologic story interprets.

The many small boys who come to the Museum with their puzzling concretions, alleged meteorites, and precious agates, or to solicit information on dinosaurs and saber-toothed tigers, are also very welcome, even though they leave grimy finger marks and nose prints all over the cabinets.

The appreciation of these public school children and their harassed teachers, who often must teach geology units in general science courses when they have no background whatever in the subject, is so real as often to be touching. I confess that we also find it rather sobering, for we have the growing conviction that helping these groups—the forgotten people, so far as geologic science is concerned—is one of the really important things that we can do. One would like to believe that, some day, geologists will see to it that every community is provided with a geology museum, however small, stocked, perhaps, from the superabundance of the great museums in our large cities. Geology will not be the loser for such generosity to the children of today, who will become the taxpayers of tomorrow. In saying this I am not unmindful of the splendid work which the Illinois Geological Survey is doing along these very lines; rather, I would here acknowledge it.

And so, at this college, while the main obligation continues to be the teaching of general geology to increasingly large numbers of general college students, we find ourselves reaching constantly toward two other somewhat diverging objectives: the preparation of a relatively small group of students for graduate study, on the one hand; and cooperation with the community, especially the public schools, on the other.

I realize that these remarks may not be wholly appropriate to this group, for admittedly they relate to the methods and purposes of geologic instruction rather than to the subject matter of our science. Also, they really present nothing new, for our experiences at Augustana have undoubtedly had their counterpart at many other like colleges. I sup-

pose that most other geology teachers have discovered, as we did, that they have been able to achieve their purposes only by taking their students into partnership with them, and that in trying to remedy the shortcomings of their small departments they have unwittingly transmuted weaknesses into elements of strength.

It is axiomatic to say that students will become interested in a field to the extent that they give themselves to it, and that instruction succeeds in the measure that it becomes a cooperative venture. Yet these principles, old as education itself and applicable to all ages and levels of instruction, are so important that it may not be too much out of order to re-emphasize them through one more repetition. And as geologists, we should realize that few subjects lend themselves to application of this basic philosophy of education as well as ours does.

SOME EASILY CONSTRUCTED MODELS FOR TEACHING OPTICAL MINERALOGY

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The study of optical mineralogy generally offers considerable difficulty to the average student of geology. Any method, therefore, which will enable the instructor to simplify the subject matter and enable the student to grasp the concepts involving three dimensions may be considered worthwhile.

A definite contribution to the simplification of teaching as well as learning the fundamentals of optical crystallography has been made by those who have suggested or described the numerous kinds of models which illustrate the various optical and crystallographic phenomena. At one extreme are those models so elaborate in their nature as to require great skill in construction. At the other extreme are models so simple in their makeup that they may be readily prepared by almost anyone. This paper deals with models of the latter group; and although these models are relatively simple in their construction, they have, nonetheless, proved very successful in teaching mineral optics, and have greatly aided those students who have experimented with them.

Most of the models described in the literature for representing the various relationships between optical and crystallographic properties consist of transparent glass, celluloid or plastic-like crystal forms within which the crystallographic axes and principal optical directions are represented by ruled lines, wires, or threads. Most of these are permanent and can be constructed with considerable accuracy. Any one model is somewhat restricted in its use; a different model must be prepared to represent each set of relationships. Such models do not, therefore, permit the flexibility required for demonstration and for student use as do the simple types described in this paper.

It is not intended here to consider models other than for biaxial crystals. If models for other optical types are desired, they can be prepared with little difficulty. It is hoped that the few examples given below will suggest to the reader ideas for making new models and simplifying or improving older ones.

Demonstration Models for Biaxial Crystals

Satisfactory models may be made of soft pine by cutting blocks of desired lengths from good quality 2 x 4 inch material. These blocks can be shaped into solid models with the crystal faces desired. For simplicity, models with only the three pinacoidal forms are illustrated here, but it will be found desirable to prepare some models with a prism form and perhaps with domes and bipyramids.

Orthorhombic models.—An orthorhombic model about 1¾ x 2⅝ x 4 inches is quite satisfactory, and when finished appears as in figure 1. The two rows of dots on each face represent small holes drilled directly toward the center of the model to

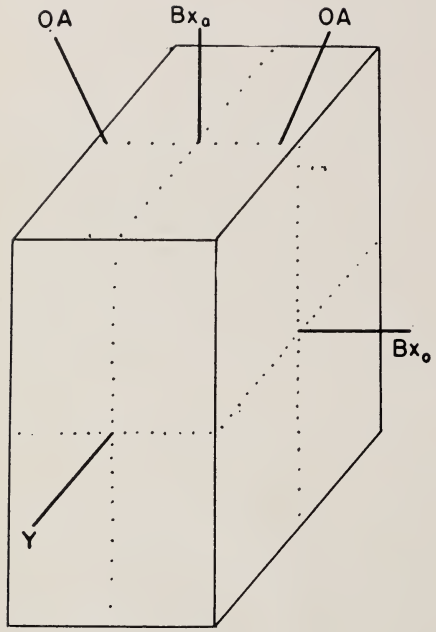


FIG. 1.

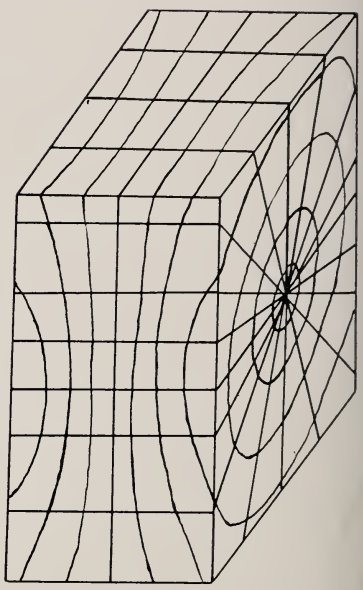
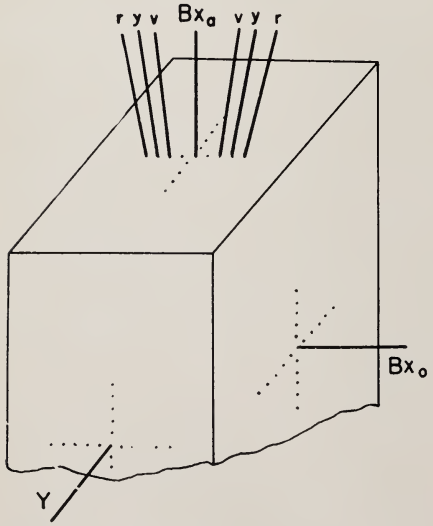


FIG. 2



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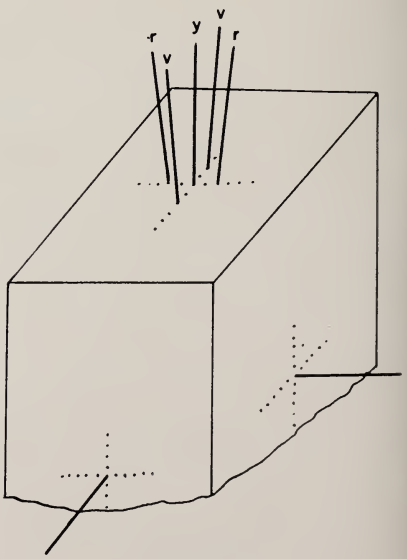

FIG. 4

a depth of about one-half inch. The points of intersection of the rows of holes lie at the centers of the pinacoids and the rows are parallel to the crystal axes. If round wooden sticks, about two inches long, are now inserted in the six holes at the intersections of the rows, the three principal optic directions X, Y, and Z may be represented in their proper positions parallel to the crystallographic axes. By inserting four more wooden sticks in the proper holes, the positions of the optic axes may be shown for a number of different optic angles. It is suggested that a relatively small number of holes be made to represent different optic angles. Holes spaced about 10° apart will be quite satisfactory.

To determine the spacing of holes, the following equation may be used:

$$D = \frac{\tan VT}{2}$$

where D is the distance from the center of the crystal face to the hole position desired, V is half the optic angle desired, and T is the thickness of the model measured perpendicular to the face to be drilled.

This model is suitable to demonstrate the unusual but instructive optical phenomenon of the lithiophyllite-triphylite series. In the most iron-poor variety the optic plane is parallel to (001) and the 2V about the b-axis is 65°. With an increase in iron, the optic angle decreases to zero and the mineral becomes uniaxial. As the iron content continues to increase, the optic plane becomes parallel to (100) and the optic angle about the b-axis increases to 90° and then begins to decrease about the c-axis until it again becomes zero and the mineral is uniaxial. With additional iron, the optic plane is believed to shift to a position parallel to (010) and the optic angle increases again about the c-axis.

Monoclinic models.—The monoclinic model as shown in figure 2 may be prepared with slightly greater difficulty. After preparing the desired crystal model, the center of the (010) face is located and radial lines drawn therefrom to the edges of the crystal face. These lines are continued across the faces in the zone of the b-axis parallel to the zone line. The radial lines might be spaced 10° or more apart. Next, concentric circles are drawn on (010), and their spacing is determined by the following equation:

$$r = \frac{\tan VT}{2}$$

where r is the radius of a given circle, V is half the optic angle desired and T is the thickness of the model measured perpendicular to (010). On the faces in the zone of the b-axis, hyperbolic curves are drawn. These can be roughly determined by computing their spacing along three of the parallel lines on each face and drawing smooth curves through these points. The spacings may be determined by use of the following formula:

$$S = \tan VM$$

where S is the distance measured right or left from the plane of symmetry, V is half the optic angle desired, and M is the distance from the parallel line to the b-axis measured on (010).

Where straight lines intersect curved lines, holes are drilled toward the center of the model to a depth of about half an inch. This model may be employed in much the same manner as the orthorhombic model. Extra sets of round sticks may be

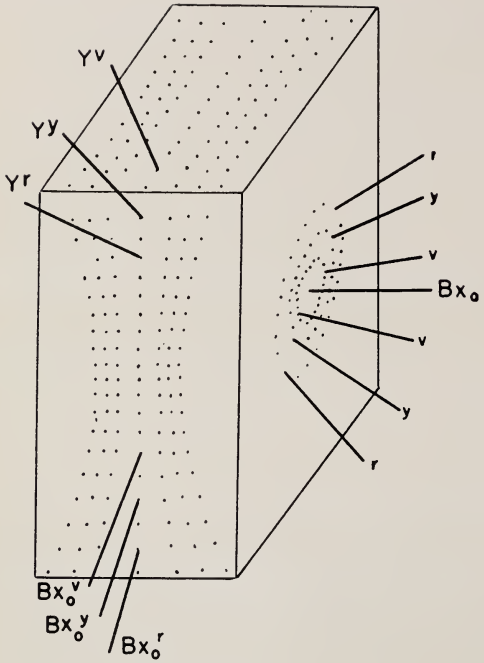

FIG. 5

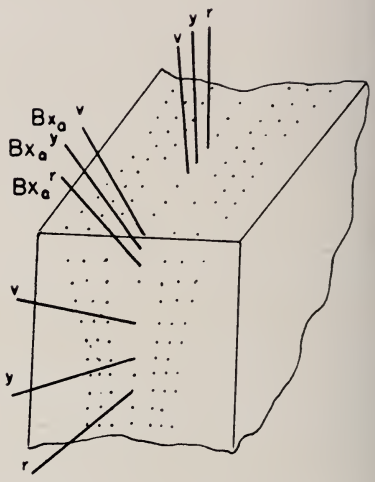

FIG. 6.

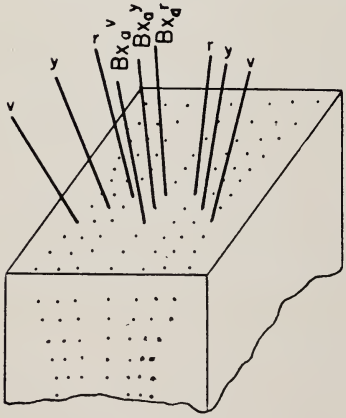

FIG. 7.

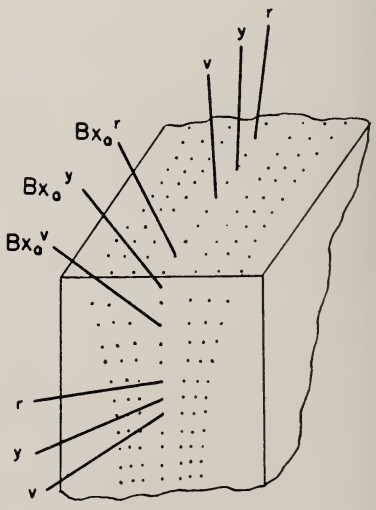

FIG. 8

used to show the positions of crystallographic a and c.

Triclinic models.—Triclinic models may be prepared by following essentially the same rules and with only slightly greater difficulty. It is suggested that only a few possible orientations be selected. Each set of holes for the directions X, Y, and Z must, in general, have an accompanying set of holes for optic axis positions.

Dispersion models.—A model like figure 1 or one like figure 3, in which a fewer number of closely spaced holes have been drilled, serves to illustrate the types of dispersion in orthorhombic crystals. Three sets of wooden sticks are used to represent the optic axes for different colors of light. One set is painted red, one yellow, and one violet. Figure 3 shows the model arrangement for dispersion of 2V with $r > v$. An arrangement like figure 4 illustrates crossed axial plane dispersion where the optic plane for red light is parallel to (100) and that for violet light is parallel to (010). The yellow stick in the position of the acute bisectrix indicates a uniaxial character for yellow light.

Figure 5 illustrates the monoclinic model for representing dispersion of 2V combined with dispersion of orientation. The principles of construction of this model are the same as those for figure 2. It is recommended, however, that there be a greater number of holes in each row and that the number of rows be reduced to seven. Figure 5 illustrates a condition in which $Bx_a = b$, crossed dispersion, and $r > v$. Figure 6 shows $Y = b$, inclined dispersion, and $r > v$. Figure 7 shows $Bx_o = b$, horizontal dispersion, and $r < v$. Figure 8 illustrates the type of relationship which exists in some minerals like epidote. If one optic axis only is observed in the interference figure, the dispersion appears $r > v$. If the other axis is observed, however, the dispersion appears reversed. Actually the dispersion of 2V is $r > v$. In figures 6 and 8 an extra hole is shown for the acute bisectrix for yellow light (Bx_a^y).

A model may also be constructed to illustrate several general examples of dispersion in triclinic crystals.

Permanent Reference Models

A very helpful set of models may be prepared for student study or reference work by employing the well-known Krantz pearwood models. After selecting the desired models, small holes are carefully drilled and long wire brads inserted to simulate the optic axes and the principal optic directions in each mineral represented. If desired, extra holes may be drilled and extra brads inserted to represent crystallographic axes as well. If the brads representing crystal axes are painted one color, those representing optic axes another color, and those representing the principal index directions a third color, each set will stand out more clearly. To produce a more finished model, the heads of the wire brads may be clipped and the rough ends filed smooth before painting.

Problem Models

Instructive problems and exercises may be undertaken by the student with the aid of inexpensive and easily acquired materials. Each student is provided with three small blocks, an inch or so long, cut from pieces of balsa wood, and roughly formed to represent the three pina-

coids of the orthorhombic, monoclinic, and triclinic systems. Substitutes for balsa wood might include any soft material like cork or art gum. In addition the student should have a supply of straight pins with different colored heads. Different colors may be designated to represent the optic axes, crystal axes, and principal index directions. By inserting the round-headed pins into the balsa wood block an unlimited variety of problems may be worked out.

In order to reproduce a given optic angle, for example, the center of the model is held directly over the index mark of a small protractor placed on the table. By sighting down upon the protractor the pins are inserted to give the proper angle. The student should be instructed to insert all pins in such a fashion that if extended inward the pins would all intersect the model's center. Inserting pins at the proper angle may be facilitated by use of a simple type of protractor. From a point at the center of the long edge of a 3 x 5 inch filing card, draw a series of radial lines spaced at intervals of 5°. If each pin is aligned with the proper radial line of this protractor before it is inserted into the balsa wood, it will point directly to the center of the model and angles will be more correctly duplicated.

Just a few types of problems and exercises are suggested here. A list of optical data for a theoretical mineral might be given the student who is required to build up a model to illustrate as many of these data as possible. Again, the instructor might prepare a model and request the student to tabulate the optical data illustrated by this model. Starting with a given model, the student might be required to predict the type of interference figure which would be obtained for a specified orientation.

Even crude models prepared of common pins and pieces of pencil eraser may be employed to good advantage by the student in his microscopic work. A simple model of a biaxial crystal with the principal index directions and the optic axes may be used to help visualize the orientation of various grains under the microscope. It will enable the student to correlate the interference figure on a particular grain with the optical orientation of that grain. Simple models of this type will permit him to visualize more intelligently the relationship between extinction angle and grain orientation.

ATOMIC MODELS OF THE SILICATES AS AN ESSENTIAL AID IN THE TEACHING OF ELEMENTARY MINERALOGY

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Most present-day courses in elementary mineralogy are actually impediments to the progress of mineralogy and geology, and are not even introductions to a *science*. The most serious defect is the lack of logical development and presentation of fundamental unifying principles. A dogmatic approach results in the emphasis falling almost entirely upon the memorization of a vast amount of miscellaneous and apparently unrelated information concerning minerals—much of it erroneous. Heretofore, such a state of affairs may have been somewhat excusable because of insufficient fundamental information. Today, however, there is sufficient information about the behaviour and arrangement of atoms in crystals so that an attempt can be made to present some of the controlling principles necessary for an understanding of miner-

FIG. 1.—Common arrangements of silicate tetrahedra: a = independent tetrahedron characteristic of olivine; b = geometric tetrahedron for comparison with *a*; c = double tetrahedra characteristic of the melilite group; d = tetrahedral chain characteristic of pyroxene; e = three-membered tetrahedral ring characteristic of wollastonite and rhodonite; f = six-membered tetrahedral ring; g = double tetrahedral chain characteristic of amphibole; h = tetrahedral sheet characteristic of the micas. Tetrahedral three-dimensional framework characteristic of the silica minerals and feldspars not shown.

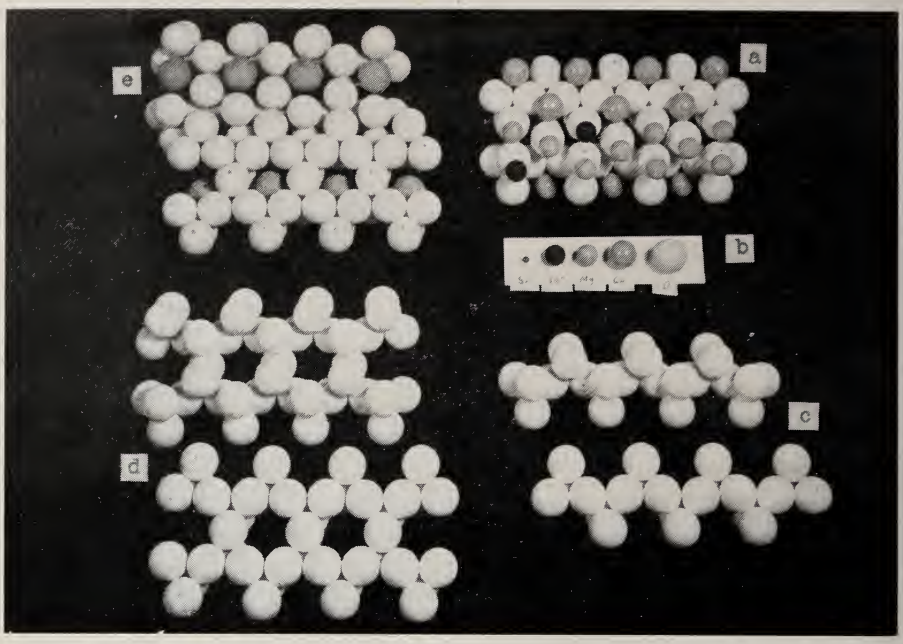

FIG. 2.—Method of assembling models: a = pyroxene showing arrangement of calcium and magnesium-iron atoms in parallel double rows (note isomorphism of magnesium and iron); b = index of atoms in pyroxene model *a*; c = method of assembling tetrahedral chains in model *a*; d = method of assembling tetrahedral double chains in model *e*; e = partly assembled model of amphibole, hydroxyl ions (gray) occupy large holes in double chains, arrangement of cations (not shown) like that in pyroxene model *a*.

als even on an elementary level.

The purpose of this paper is not to present a complete elementary treatment of such principles but simply to call attention to them and to show how readily they may be illustrated by atomic packing models of minerals. The value of this approach is particularly well demonstrated by the insight which it gives into the relations of the extremely complicated silicate group of minerals. However, before describing the atomic packing models, several highly simplified principles will be given first so that the significance and use of the models can be fully appreciated:

(1) The constituent elements occur as spherically shaped ions.
(2) Each kind of ion (Fe^{2+}, O^{2-}, Fe^{3+}, etc.) has a characteristic size (in general anions are larger than cations).
(3) Anions are attracted so as to touch neighboring cations and vice versa.
(4) The number of anions that can surround a cation (and vice versa) is controlled by the relative sizes of the respective ions.
(5) Different kinds of ions that have similar sizes (e.g. Fe^{2+} and Mg^{2+}) can equally well occur in the same kind of position in a crystal structure (isomorphism).

The most important conclusions to be derived from these principles are that most minerals, including silicates, can be considered as composed

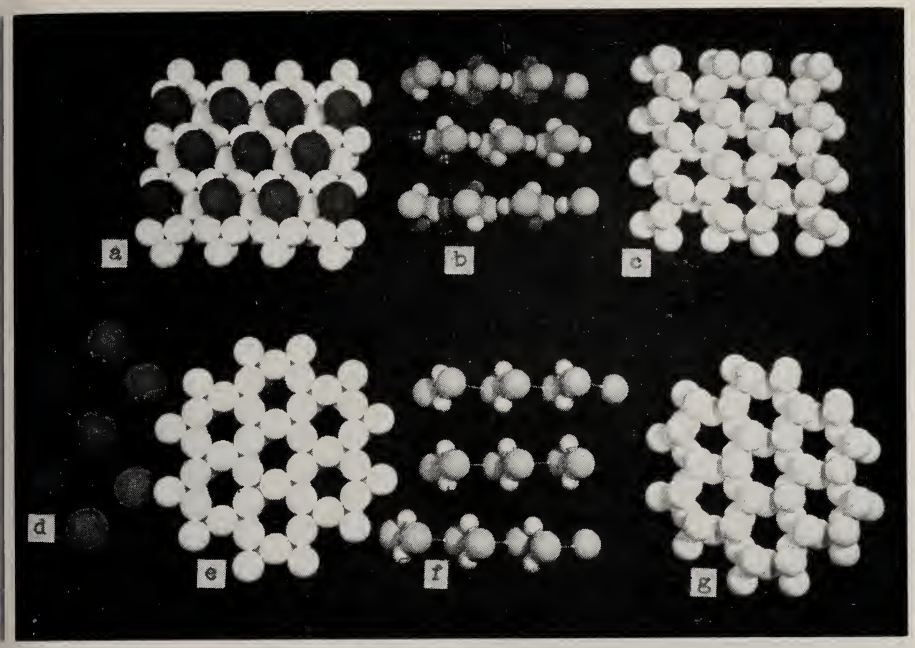

FIG. 3.—Method of making models with interchangeable parts that can be easily assembled and disassembled: a = silicate sheet with large potassium atoms (dark) resting in holes in sheet. b = strings of hydroxyl ions (large gray spheres) and magnesium-iron atoms which form a layer between silicate sheets *a* and *c*. Threefold arrangement of magnesium and/or iron atoms is characteristic of biotite and talc. c = silicate sheet. d = potassium atoms. e = silicate sheet identical to rectangular sheet *a* but with tetrahedra at corners removed in order to show hexagonal symmetry of sheet. f = strings of hydroxyl ions and aluminum atoms (small white spheres) which form a layer between silicate sheets *e* and *g*. Twofold arrangement of aluminum atoms is characteristic of muscovite, pyrophyllite and kaolin. g = silicate sheet identical to *c* but with corner tetrahedra removed in order to show hexagonal symmetry of sheet.

of ion spheres of different sizes, and that many of the properties of minerals depend upon the relatively simple geometric ways in which these spheres can be packed repetitively. An elementary account of these principles can be found in Stillwell (1938). Data on the sizes of ions can be found in Evans (1948).

It should be possible, therefore, to show the application of these principles by means of models of minerals constructed with spheres of different sizes representing the different atoms. Spheres of cork probably are the easiest to use. The Armstrong Cork Company makes cork spheres in any size from 3/8 to 3 inches in diameter. Entirely satisfactory models can be made with relatively few sizes. The following sizes have been found to be suitable:

1¼″ = oxygen, hydroxyl, fluorine, and potassium (1¾″ has been found to be more satisfactory for potassium in the micas)

1″ = calcium, sodium

¾″ = magnesium, iron, aluminum (½″ would be more accurate for aluminum)

9/32″ = shot or ball bearings for silicon

The use of different colors for the different kinds of atoms adds to the effectiveness of the models. The spheres can easily be joined together by means of heavy pins or brads from which the heads have been cut off. Models of particular minerals can be constructed from the data in Bragg (1937).

The fundamental unit of construction of the silicates is the so-called silicate tetrahedron which consists of a silicon atom surrounded by four oxygen atoms. This unit well illustrates the control on arrangement of atoms by their relative sizes because the sizes of silicon and oxygen are

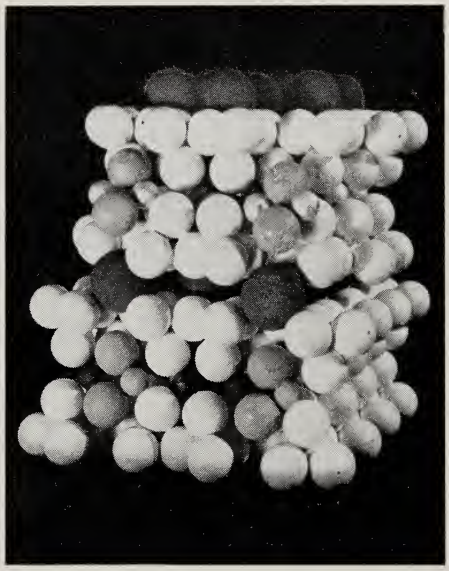

Fig. 4.—Composite model of mica made by assembling units shown in figure 3. Lower half represents biotite assembled from units *a*, *b*, and *c* in figure 3. Upper half represents muscovite assembled from units *d*, *e*, *f*, and *g* in figure 3.

such that four oxygen atoms can just fit around each silicon atom (figure 1). One of the most important causes of the complexity of the silicate minerals arises from the variety of ways in which the silicate tetrahedra can be arranged (figure 1). In fact, the simplest and probably the most instructive method of making a model of a particular silicate mineral is to assemble several of the tetrahedral groups that compose the major part of that mineral, such as independent tetrahedra for olivine, single chains for pyroxene, or sheets for mica. In general, it will be found that these groups pack together rather snugly and that the other atoms in the crystal fit in the interstices. Large atoms fit in the large interstices and small atoms in the small interstices. Examples are shown by figures 2, 3, and 4.

The models are particularly instructive if the groups can easily be disassembled and reassembled by students. Figure 3 shows an example in which the groups are interchangeable and can be assembled in various combinations to illustrate almost all the sheet minerals.

Models such as those that have been briefly described illustrate vividly and fundamentally many of the varied properties of the silicates, such as isomorphism, derivation of the chemical formulae, cleavage, hardness, many of the optical properties; why certain alteration products may be favored; and why melts of certain silicates are viscous whereas others are fluid.

Grateful acknowledgment is made to Dr. Ralph E. Grim of the Department of Geology and the Illinois State Geological Survey, who has long recognized the value of atomic models in his researches on the clay minerals and who called to my attention the convenience of cork spheres. Mr. Merle Williams, a student in the Department of Geology, assembled the excellent models shown in the illustrations.

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GLACIAL LAKE MERRIMAC

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Named for a town at the crossing of Wisconsin River by the Elroy division of the Chicago and Northwestern Railway, Lake Merrimac came into existence in this part of the Wisconsin valley when the Green Bay lobe began to retreat from its terminal (Johnstown) moraine. The moraine and its outwash, blocking the valley, served as an effective dam, and the lake lengthened northeastward as the retreat continued. Its level appears to have stood at 850 to 860 A.T. during this time.

Overlooking the lake on the north was the southern of the two Baraboo Ranges which, 18 miles northeast of the drift dam, terminates abruptly where joined by the converging North Range. Here the upland surface drops off from 1200 to altitudes below that of the lake. Had there been no drainage into Lake Merrimac other than that of the adjacent retreating glacial front, and had no lowering from outlet erosion occurred, the lake would have continued to lengthen and expand as the glacier retreated north and east of this end of the Ranges and would have flooded the low country about Portage and north down the Fox River valley. Indeed, the upper Wisconsin River would today be a part of the St. Lawrence drainage system.

The possibility of such continued enlargement, however, was denied because that same ice front had been confining a higher and far larger lake on the north side of the Ranges, which abruptly began discharging southward into Lake Merrimac when the eastern end of the Ranges was freed by the retreating ice front.

Lake Wisconsin, largest of all such water bodies within the state, was formed when the advancing Green Bay lobe closed the Devils Lake gap in the South Range. Glacial ice and glacially ponded water then largely replaced the former free drainage of the upper Wisconsin River through this gap. This large lake found an outlet down Black River to the Mississippi north of LaCrosse. Because the ice built a bulky moraine (Johnstown) in two places across the Devils Lake gap, effectively blocking it against re-use by Wisconsin River after retreat from this position, Lake Wisconsin continued to exist and was enlarged eastward as the ice edge shrank back, until the abrupt east-pointing prow where the Ranges join and terminate was ice-free.

With lower surfaces thus exposed the glacial damming of Lake Wisconsin came to an end. The level of the new outlet around the east end of the upland was about 120 feet lower than that leading to Black River. The first 80 feet of this marked drop in level involved the entire lake. There then emerged a high place in the lake bottom, a group of submerged hills of sandstone in the region of The Dells, 20 miles northwest of the new outlet. They became a far more durable dam than glacial deposits could be and held back a large portion of the lake from further abrupt lowering. The

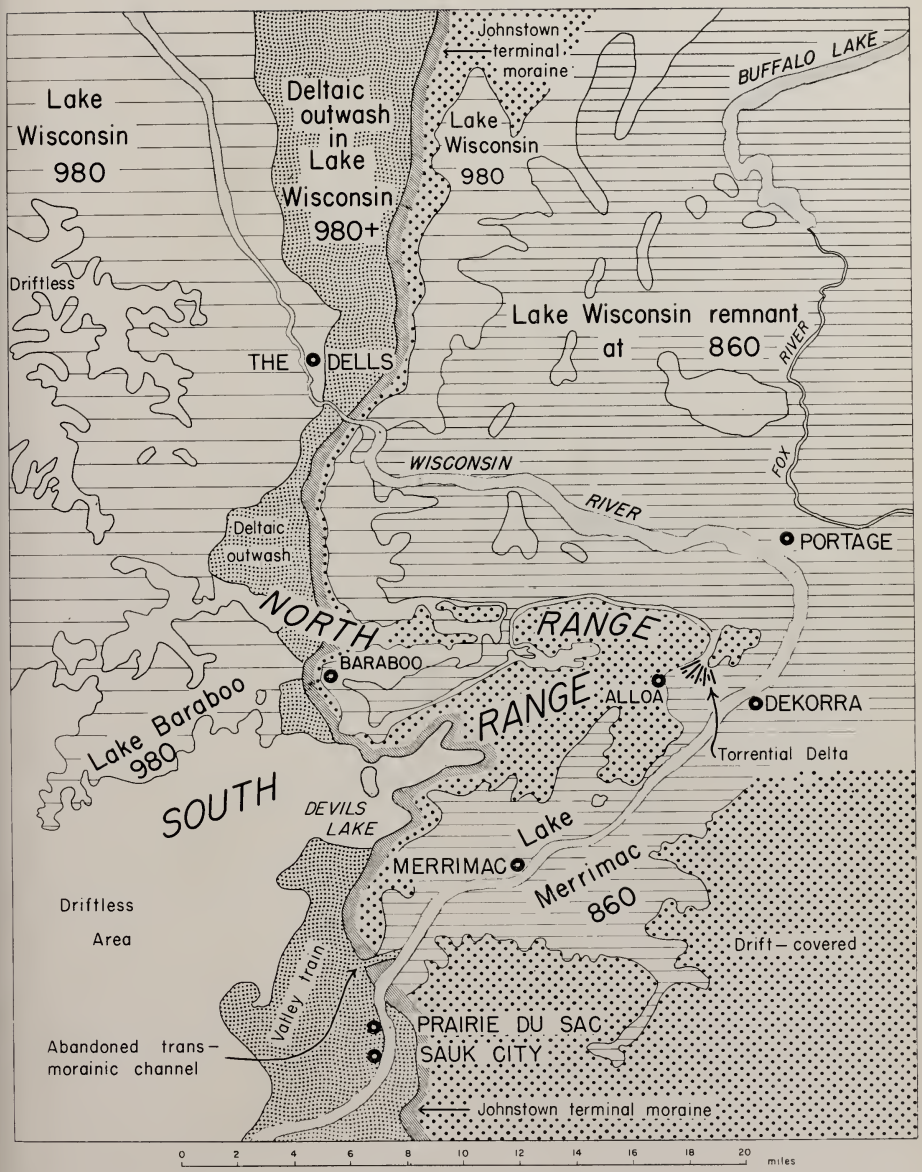

FIG. 1.—Glacial Lake Merrimac

postglacial Wisconsin River is still at work incising this barrier on which it found itself superposed.

The southern and southeastern part of the dismembered lake, however, continued to lower rapidly as obstructing drift deposits were eroded by the new outlet. The details of lowering involved the existence of Lake Merrimac, into which the discharge poured at the time the glacial dam failed, the building of a torrential delta at the head of that lake by the rapid lowering of Lake Wisconsin, followed immediately by the trenching of this delta as Lake Merrimac's own outlet near Prairie du Sac was rapidly deepened and its level lowered by the greatly increased volume of its discharge.

The details are as follows: When retreat south of the Ranges began, an extensive valley train heading at the terminal moraine reached down the Wisconsin valley across the Driftless Area. Where it rested against the outer face of the Johnstown moraine its altitude ranged between 860 and 880 feet A.T., and its gradient thence down-valley was gentle. Rather than the moraine, this valley train was the effective dam for Lake Merrimac. Two channels were promptly cut into the moraine to the level of the outwash apron in front, one now deeply incised by later use and carrying Wisconsin River today, the other a narrow abandoned trench somewhat more than a mile long, exceeding 80 feet in depth and its floor 30 to 40 feet lower than the 850-860 level of the lake.

No shore lines of Lake Merrimac are known, and the only record of the lake's level is the torrential delta east of Alloa and just south of the east end of the Ranges. Its surface is somewhat undulatory, its southern or frontal slope is rudely parallel with the foresets revealed in excavations and its back slope is steep and irregular as befits an ice contact. An alluvial fan stands on the northern part of the delta top, sloping southward and truncated on the north by the same ice contact slope.

Topography alone would hardly establish the interpretation given this hill. There is no denying it, however, when the sections in the gravel pit on the south slope are examined. For 40 or more vertical feet, unbroken foresets of extraordinarily open-work coarse gravel dip southward. Except for one growing delta at the head of Franz Josef fiord, East Greenland, the writer has never seen a more bouldery delta deposit. Most of the boulders are crystallines up to 3, 4, and even 5 feet in maximum diameter. Most of them lie in a cobble gravel; a few are imbedded in pebble gravel. No foresets composed dominantly of boulders were seen, nor any foresets largely of sand. Subordinate to the crystallines are sandstone and dolomite boulders, and still less common but highly significant are widely distributed cobbles and boulders of a pink clayey till. The largest till boulder seen was 3 feet in diameter.

Although all these boulders must have been rolled across the top of the delta to reach the foresets where they rest, there is no channel leading to this delta, no adequately extensive drift surface high enough to have carried a free-surface stream to the delta head. The ice contact slope, if correctly interpreted, records the debouching of the torrential stream directly from the retreating ice front.

The very brief episode of discharge was neither preceded nor followed by any noteworthy outwash

deposition. It therefore appears to record unusual and short-lived conditions that developed just before the ice withdrew from contact with the Ranges. There is strong suggestion that the discharge initiated failure of the ice barrier between lakes Wisconsin and Merrimac, that the hydrostatic head of 120 feet caused a leakage under and through crevasses in the decaying glacial front. The till cobbles and boulders are difficult to explain unless they record quarrying beneath the ice and a very short transportation *upgrade* downstream.

Comparison with the Gregory Valley delta at the head of Franz Josef fiord is interesting although the argument derived is only by analogy. The observed boulders of this Greenland deposit lie on the delta top, extending to the very edge, and obviously indicating that others have gone over the edge to become a part of the foreset structure. Slabby boulders lie in imbricate positions despite their diameters of several feet, a relationship which the existing Gregory stream is wholly incompetent to produce.

These boulders were traced back to the fairly recent breaking of a glacial dam several miles up the Gregory Valley, behind which was impounded a lake*. Velocity for their transportation was provided by the valley's gradient instead of a hydrostatic head, and they were doubtless swept all along the lower valley by the brief torrent when the dam broke. The delta itself is a normal deposit and only the surface boulders are to be compared with those composing so much of the Alloa deposit.

Although no channel leads to the top of the Alloa delta, there is a glacial river channel trenched some 30 feet deep into its eastern part. This was noted by Thwaites,† who interpreted it as the initial outlet when "the ice margin cleared the east end of the Baraboo Bluffs" and "the level of waters impounded in front of the ice fell from about 980 . . . to about 840 feet." According to the present writer, it is the Alloa delta which records initial discharge, and the channel was made after the ice had been cleared away sufficiently to allow standing water at the subsiding Lake Wisconsin level to reach the ice-contact head of the delta. Thus, although the lower portion of dismembered Lake Wisconsin dropped 120 feet to Lake Merrimac's level during the growth of the Alloa delta, no debacle occurred during this failure of the ice barrier at the east end of the Ranges.

Excavation of the channel was completed while the retreating glacial front stood less than three miles to the east. At that distance, the drift surface beneath the glacier was close to 800 feet A. T., and when it became exposed, the channel was abandoned and lakes Merrimac and Wisconsin came to the same level, connected by a strait 4 to 5 miles south of Portage.

But Lake Merrimac was lowered about 30 feet during the channel's life, by reason of the great increase in its discharge volume across the moraine and outwash near Prairie du Sac. The time involved was only that required for about three miles of glacial retreat, a few centuries at the most. In the fact that the delta records none of this lowering, we find additional support for the concept that the extraordinary conditions (penetration of the glacial bar-

* Boyd, L. A. "The Fiord Region of East Greenland," Am. Geogr. Soc. Spec. Publ. No. 18, pp. 185-193.

† Thwaites, F. T. "Pleistocene of part of northeastern Wisconsin," Geol. Soc. America, Bull. Vol. 54, 1943, p. 120.

rier by water under high pressure) produced an extraordinary volume of discharge for an extraordinarily short time.

The two competing transmorainic channels near Prairie du Sac continued to be deepened after lakes Wisconsin and Merrimac became confluent, but the northern one was shortly abandoned and all subsequent drainage, including that from both Early and Late Oshkosh in Fox River drainage, has continued to deepen the winner in the contest, the present Wisconsin River route past Prairie du Sac and Sauk City. Lake Merrimac slowly dwindled to a series of extensive marshes which now are largely submerged beneath an artificial lake back of the power dam at the moraine transection north of Prairie du Sac.

CURRENT EVALUATION OF THE CAMBRIAN-KEWEENAWAN BOUNDARY[1]

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In the Lake Superior region the youngest of pre-Cambrian sequences is the Keweenawan system, 30,000 to 60,000 feet thick; of this system the youngest unit which appears universally recognized as undoubtedly Algonkian is the 12,600 foot Freda sandstone of the Upper Keweenawan Oronto group.

South of the Lake Superior region in the Upper Mississippi Valley, the oldest of recognized Paleozoic sequences is the Upper Cambrian, Croixan Series; of this, the oldest unit universally conceded to be Paleozoic in age is the Mt. Simon sandstone member[2] of the Dresbach formation.

In a kind of no-mans-land of controversy between the obviously Keweenawan units and obviously Croixan units is a group of redbed sandstones and shales ranging up to 2600 feet in thickness, to which Thwaites (1912) applied the term Bayfield group. It now seems highly probable, especially as the result of the heavy mineral studies by Tyler and Thiel (1940), that the Wisconsin Bayfield is represented in Minnesota by similar sediments, there referred to as Red Clastics, Fond du Lac, or Hinckley, and in Michigan by the Jacobsville sandstone. It is the age relations of these units, then, that come into question. The term Bayfield, when used below, is employed as embracing all of them.

Broader regional relations.—The problem fundamentally is whether the Bayfield group is structurally, stratigraphically, and in time more closely associated (1) with the Keweenawan, Oronto group, (2) the Cambrian, Croixan series, or (3) independent of either.

The distribution of strata belonging to the Oronto group, as indicated in figure 1, is confined to the inner portion of the Lake Superior Basin. The distribution of Bayfield strata areally is much more extensive and not necessarily related to the distribution of the Oronto group. The two groups occur together only in the Lake Superior region, and it is this writer's opinion that the occurrence is coincidental. The two sequences occur together *in the same outcrop* at only two localities (Thwaites, 1912): on the south fork of Fish Creek, near Ashland Junction, Bayfield County, and on Middle River in eastern Douglas County, both in Wisconsin. In both instances they occur in the drag zone along the Douglas thrust fault, and/or its eastern extension (fig. 8).

The basal contact of the older, Oronto group is in all cases with the immediately preceding Middle Keweenawan eruptives. The upper contact of the Oronto group is known only from the two localities cited and probably also from deep wells at Ashland, Wisconsin (Thwaites, 1912, p. 65), and Stillwater, Minnesota (Hall et al., 1911; Thwaites, 1931, etc.).

At the two outcrops conformability has been claimed, but since the

[1] Published by permission of the Chief, Illinois State Geological Survey.

[2] The Illinois Geological Survey regards the Mt. Simon as a separate formation rather than a member of the Dresbach formation.

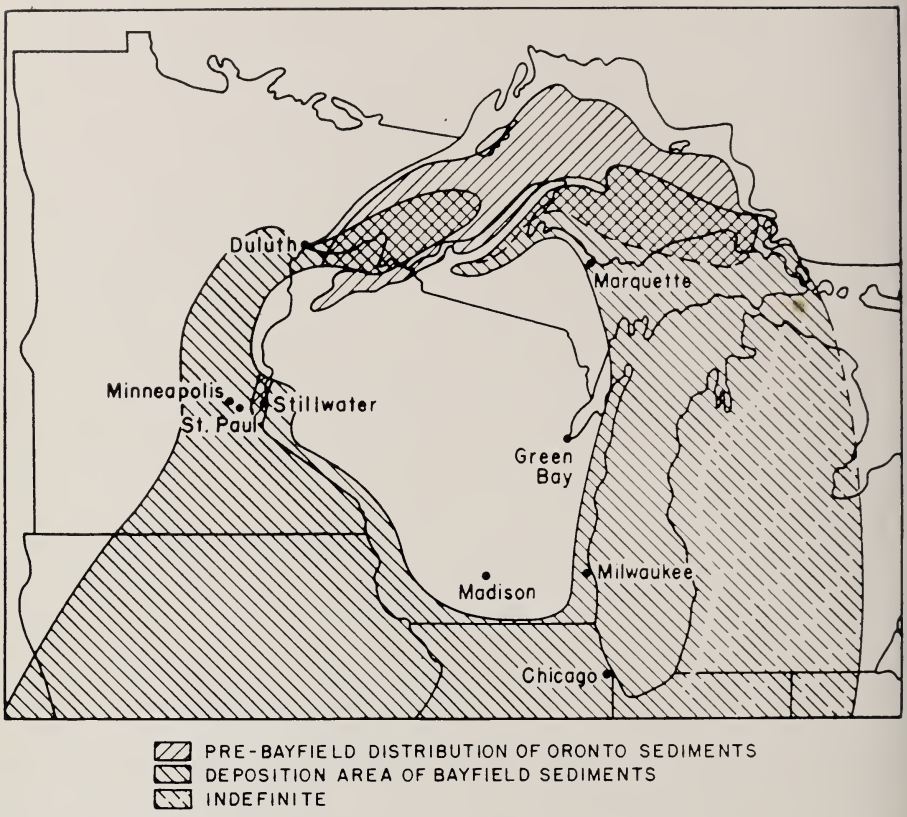

Fig. 1.—Regional Distribution of Oronto and Bayfield Sediments.

strata stand nearly vertical, this appearance of conformability can be misleading, as pointed out by Van Hise and Leith (1911) in connection with Keweenawan-Huronian relations under similar conditions. Furthermore, in the area of the two outcrops and the Ashland well, the attitude of the Oronto beds, lying as they did in the center of the broad Lake Superior syncline, should have been nearly horizontal at the time the Bayfield sediments were deposited on them. Such concordance of strata does not necessarily imply close age relations.

Furthermore, when we consider the regional relations of the Bayfield group, we find that, whereas in a very limited area it is in basal contact with the Oronto sandstone, over a far greater extent it rests nonconformably and in a relatively horizontal attitude on a basement complex of pre-Keweenawan gneisses, schists, and slates, cut by acid and basic plutonics and dike rocks of both Keweenawan and pre-Keweenawan age. The upper contact of the Bayfield, on the other hand, is everywhere with the white sandstone of the Mt. Simon member of the Dresbach formation and the Dresbach and Bayfield maintain conformable relations over all the Upper Mississippi Valley[3] and Upper Great Lakes regions. The dif-

[3] In Illinois no basis has been found for separating the Bayfield and Mt. Simon sandstones, and the Illinois Geological Survey classifies all the sandstone between the pre-Cambrian crystallines and the Eau Claire formation as the Mt. Simon formation of Upper Cambrian age (Templeton, 1950).

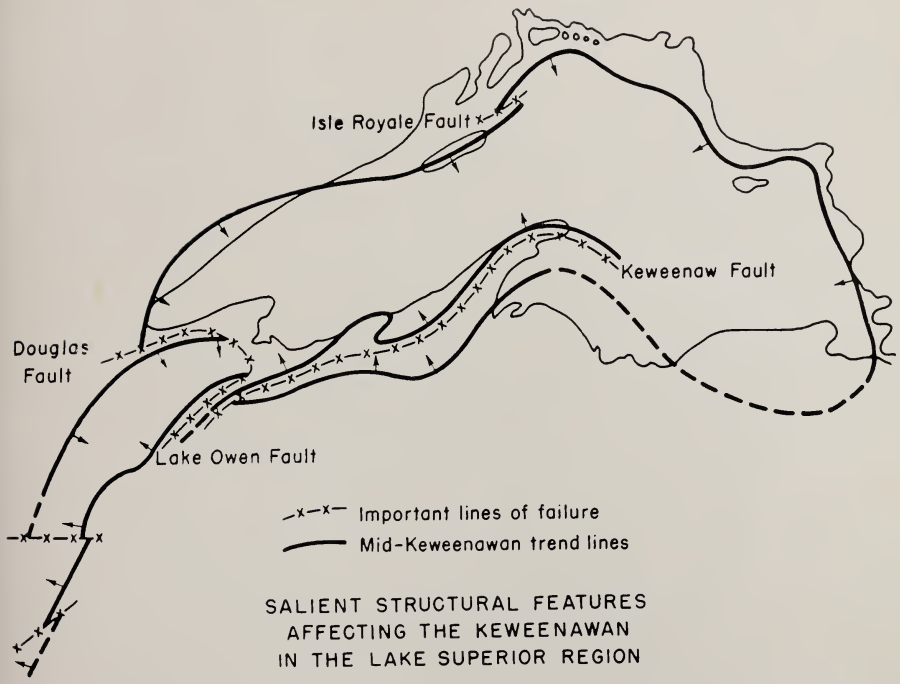

Fig. 2.—Salient Structural Features Affecting the Keweenawan in the Lake Superior Region.

ficulties indicated by Schwartz (1936, pp. 24-25) and others in drawing Red Clastic and Hinckley and Mt. Simon boundaries in the subsurface suggest a high probability that the three units are gradational as well as conformable.

These broad and simple relations might seem to leave no doubt that the age relations of the Bayfield group are with the Cambrian but for the troublesome intervention of seemingly local phenomena, some of which at first glance appear to preclude a Cambrian age. A reassessment of these seeming anomalies is the primary objective of this paper.

Anomalies Opposing Cambrian Assignment of Bayfield

Pre-Cambrian faults.—Those favoring a pre-Cambrian age for the Bayfield stress the fact that in Wisconsin, Minnesota, and Michigan, the Bayfield along with the Oronto is cut by great thrust faults which moved parallel to the dip of the fault plane. They interpret these movements as a part of the orogeny which closed the Algonkian.

That the Bayfield and Oronto are jointly cut by extensive faulting along the Douglas Fault in Wisconsin cannot be denied (see Thwaites, 1912). However, the requirements

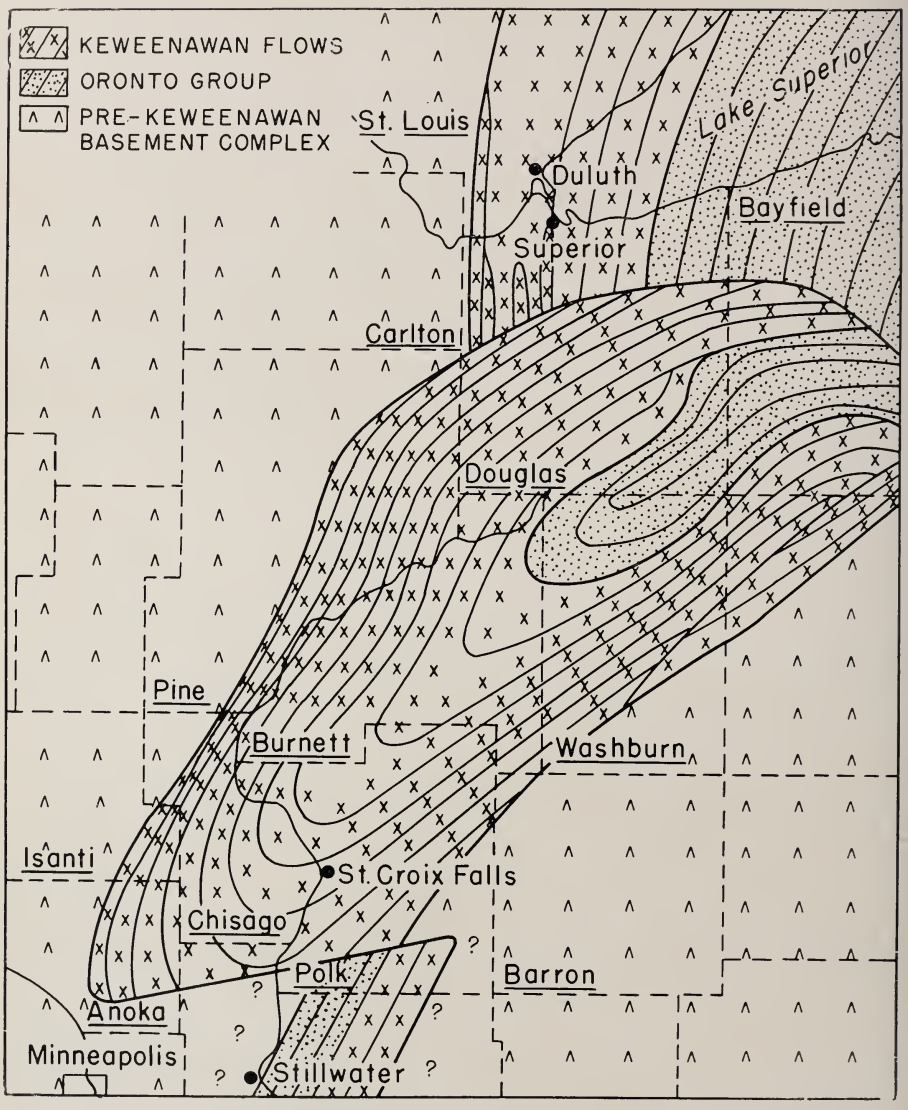

Fig. 3.—Pre-Bayfield Bedrock Surface in West Part of Lake Superior Region.

to account for the type of late pre-Cambrian movements which sheared and disrupted the Lake Superior syncline are, not movements parallel to the dip of the fault plane, but extensive horizontal displacements, north of east, measurable in miles along the Douglas thrust, with only a moderate degree of vertical component. The accompanying map (fig. 2) shows that this latter type of movement must have taken place, and that a thrust block, bounded laterally by the Douglas and Lake Owen faults, respectively, did so move in pre-Bayfield time. However, the present attitude of the Bayfield beds along the fault (and of the

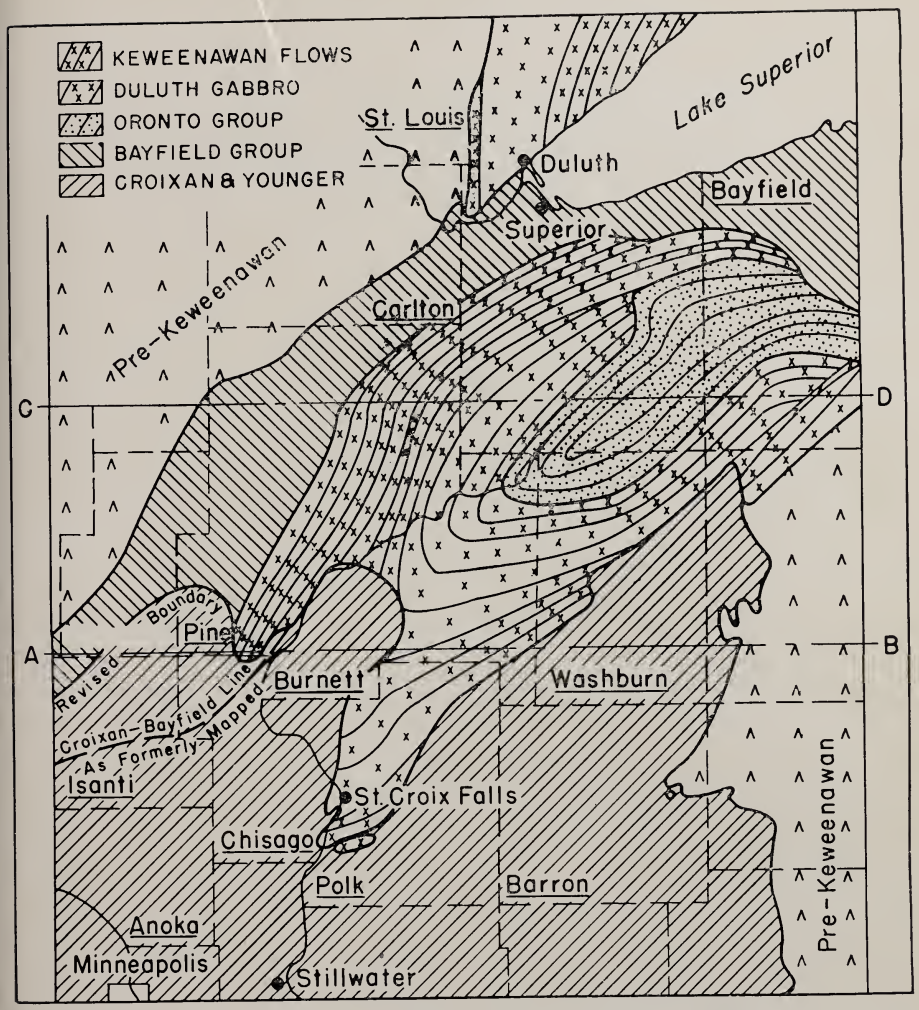

Fig. 4.—Croixan (Bayfield)-Keweenawan Areal Relations in West Part of Lake Superior Region.

Oronto beds dragged up along with them) indicates an extensive thrust movement parallel to the dip of the fault plane with a vertical component of close to 3000 feet of displacement.

That there have been two movements, one pre-Bayfield and one post-Bayfield, seems clear from both regional and local considerations.

In Wisconsin, no evidence is at hand that will permit the dating of the second (post-Bayfield) movement along the old thrust plane. Like the Douglas fault, the Keweenaw fault in Michigan appears to have been pre-Bayfield in origin with postulated secondary movement that, on the downthrust southeastern side, visibly cuts only Jacobsville (Bayfield) beds. But at Limestone Mountain, only a few miles southeast, an isolated outlier of Ordovician, Silurian, and possibly Devonian beds

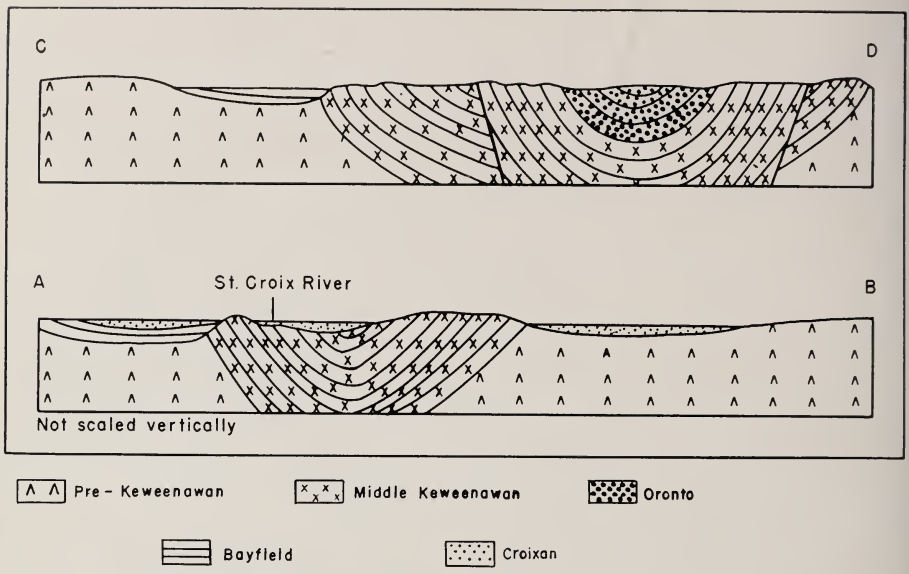

Fig. 5.—Cross Sections Along Lines A-B and C-D of Figure 4.

(Case and Robinson, 1915; Thwaites, 1943) is profoundly shattered by structural movements that can most logically be assumed to be simultaneous with the second period of movement along the Douglas and Keweenaw fault planes.

Douglas fault in Minnesota.—In Minnesota, the structural evidence is less clear and the seeming anomalies more numerous. It has been rather generally assumed that the Douglas fault swings southerly soon after entering Minnesota and continues until lost under glacial drift and/or Paleozoic cover. Unfortunately, the trap-sandstone contact, clearly shown by numerous exposures to be a fault in Wisconsin, is not exposed in Minnesota. Indirect evidence supporting a fault relationship between Bayfield-type sandstone and Keweenawan extrusives seems less than conclusive to the writer. This evidence revolves around two localities, Kettle River and Pine City.

On Kettle River, both Irving (1883, pp. 244-246, figs. 8 and 9, pl. 14) and Upham (1888, pl. 55) describe, map, and illustrate the Hinckley-trap contact in a manner to indicate a nonconformity and a sedimentational contact of horizontal sandstone on steeply dipping lavas. But C. W. Hall (1901, pp. 324-325) states: "Along the entire distance of the contact, the attitude of the sandstone is that of a greatly disturbed formation; it is broken in places in blocks, some of them of huge dimensions lying in many different directions. They have every appearance of being shattered by profound crustal movements." Here is obviously an area calling for further detailed study.

At the Pine City locality, very steeply eastward-dipping lavas outcrop in Snake River at the outlet of Cross Lake, whereas a well drilled scarcely a mile to the west encountered no lava and terminated at a depth of 700 feet in red sandstone. This relationship, plotted on a twen-

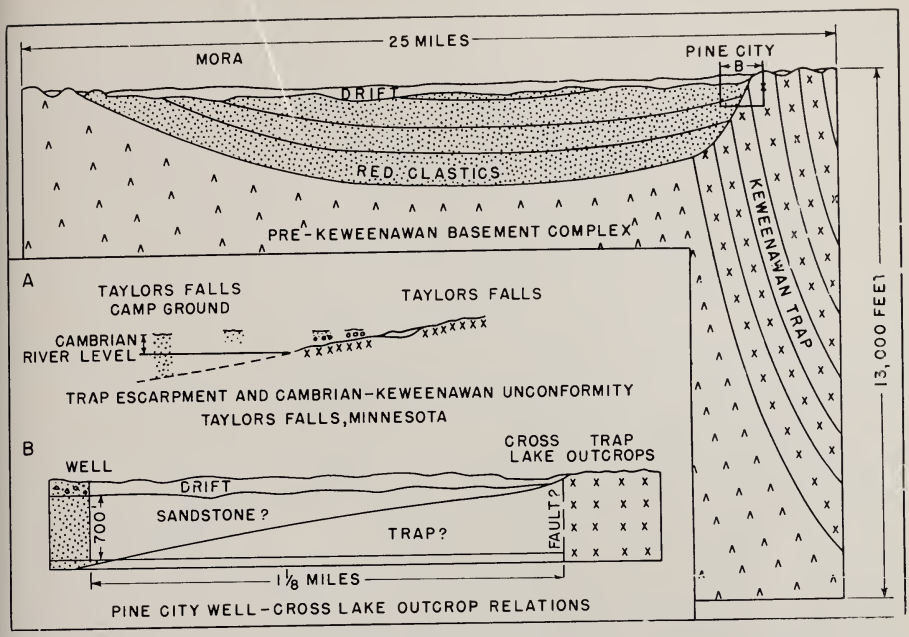

FIG. 6.—Postulated Bayfield-Keweenawan Relations in the Pine City-Mora Area.
a. Actual Pre-Croixan Erosian Surface Profile at Taylors Falls, Minn.
b. Postulated Pre-Bayfield Erosion Surface Profile in Pine City Area, on Scale 1:1.

ty-to-one exaggeration by Thiel (1947, p. 194) gives thus a relief that seems to demand a fault postulate. However, the same relationship plotted on a one-to-one scale by the writer (fig. 6b) compares very closely with the slope of the trap-sandstone contact exposed at Taylors Falls, Minnesota (fig. 6a), a place where the sedimentational nature of the contact is demonstrable and the Cambrian age of the sandstone unquestioned.

Gravity-meter evidence.—G. I. Welch (1941) published the result of a gravity-meter traverse across the lava-sandstone contact a short distance south of the Pine City well. The observed anomaly he interprets as indicative of a fault of about 11,000 foot displacement.

Actually Welch's data do not constitute proof of the existence of a fault at this place. According to his interpretation, which assumes (1) that there is a fault and (2) that the upthrown side of the fault is all trap and the downthrown side is sandstone on trap, then the anomaly shows that 11,000 feet of sandstone is present on the downthrown side of the postulated fault.

If, on the other hand, there be postulated a situation as illustrated in figure 6, the recorded gravity anomaly reflects quite different conditions which do not necessarily involve faulting. Let us assume the sandstone sequence to be approximately 2000 feet thick, normal for the Hinckley-Red Clastic succession. Let us further assume that to the east the sandstone abuts the Keweenawan lava along a steep pre-Bayfield erosional slope similar to the pre-Croixan erosional slope at St.

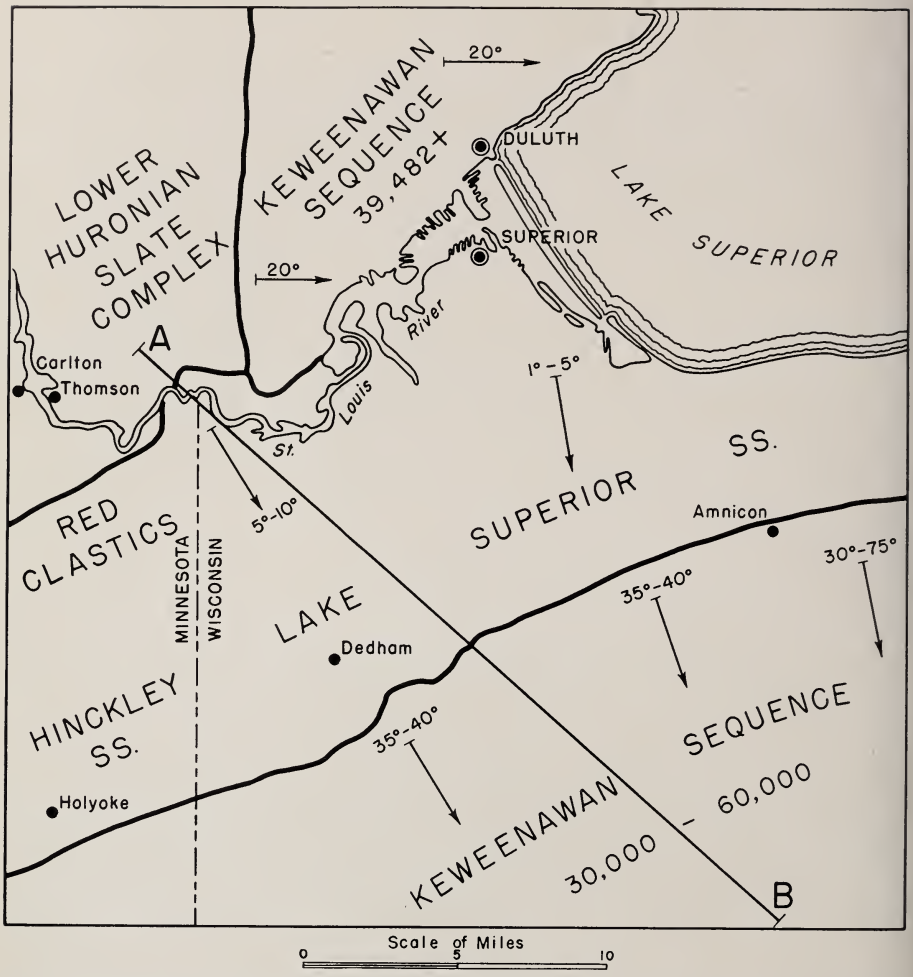

FIG. 7.—Dip-strike Relations of Keweenawan Sequence and Bayfield Equivalents at West End of Lake Superior.

Croix Falls. Finally, concealed beneath the sandstone is a steeply dipping contact between the highly inclined lavas to the east which represent the west limb of the Lake Superior syncline and the pre-Keweenawan complex of granites, gneisses, schists, slates, etc., to the west. The gravity anomaly may thus be a consequence of a line between a western belt of sandstone on various crystallines of lesser density than diabase and an eastern belt of dense diabase extrusives. The steep westerly sloping contact between lava and sandstone and the steep easterly sloping contact between lava and basement complex might well combine to resolve a sharp line of gravitational anomaly. This is not to say that faulting of limited extent may not incidentally be associated with this zone.

Tilting of Bayfield strata.—The facts that the Red Clastics in Minnesota dip at angles up to 10° and the

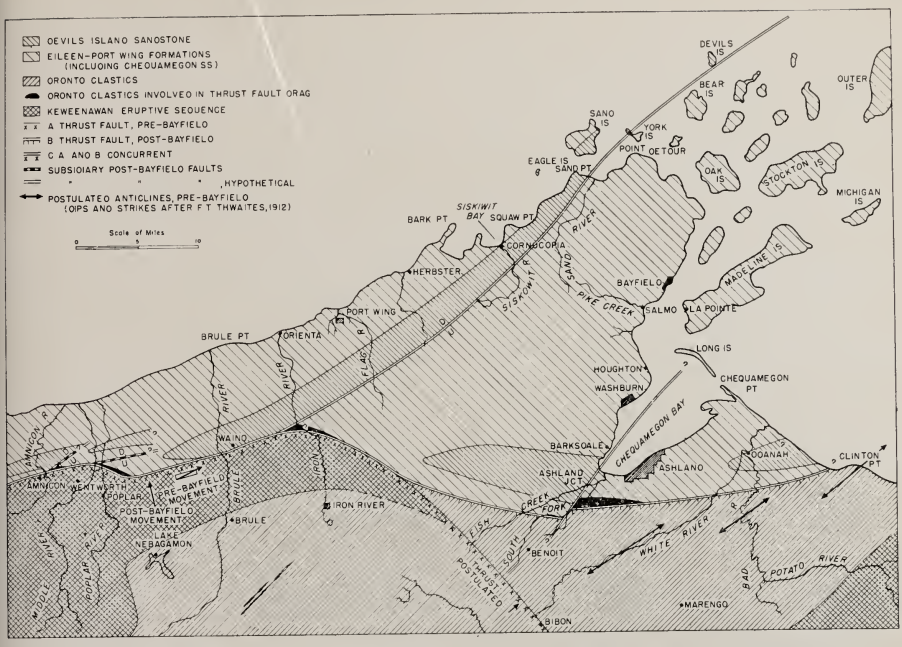

FIG. 8.—Postulated Pre- and Post-Bayfield Fault Patterns in the Bayfield Type Area.

overlying Hinckley sandstone dips commonly from 1°-2°, whereas the St. Croixan beds to south and east are essentially flat-lying, have been cited (Atwater and Clement, 1935) as evidence for the pre-Cambrian age of the Hinckley-Red Clastics (fig. 7). The increase in dip downward in the sequence may be a reflection of initial dip of the basal beds close to the contact with the basement complex; but the writer interprets it to be a consequence mainly of regional uplift of the country lying to the northwest and north of the Hinckley-Red Clastic belt of outcrop (figs. 3, 4, and 5).

That such a regional rise did take place is suggested by the contrast between Bayfield relations in southern Minnesota and in east central Minnesota. In the former area, the Bayfield equivalents in the subsurface are flat-lying, uniform in thickness over a wide area, and conformably overlapped westward by the Dresbach against the granite basement (Hall et al., 1911, pl. V; Couser, C. W., 1935). In the latter area, on the other hand, observable dips are present in sandstones of Bayfield age, outliers occur well beyond the main outcrop belt, and the strata, along with the overlying Croixan beds, have been truncated by erosion (figs. 5, 6, and 7).

Light mineral data. — Atwater (1935, p. 318) considered that the Hinckley sandstone could be distinguished from the Mt. Simon (Croixan) on the basis of secondary enlargement of quartz grains in the latter formation. However, secondary enlargement of quartz has been noted in some Croixan sandstones as well.

Association with diabase.—Hall et al. (1911, p. 48) cite the association

of diabase with red sandstones in a well at Stillwater, Minnesota, as evidence for the Keweenawan age for the Red Clastics of the Minnesota subsurface. Yet of ten Minnesota wells which passed through the redbeds and into pre-Cambrian crystallines (Hall et al., 1911), only this one encountered diabase. Of the remainder, one penetrated quartzite, one "crystalline rock," and seven granite. Except for the Stillwater well, the greatest thicknesses of Hinckley-Red Clastic strata reported in the Minnesota subsurface are at Minneapolis (1200 feet) (Schwartz, 1936, p. 222) and at Mankato (over 1289 feet) (Hall et al., 1911, p. 141). In the Stillwater well, over 2000 feet of redbeds are reported to have been penetrated, above nearly 500 feet of diabase (Hall et al., 1911, p. 366; Thwaites, 1931, pp. 740-742, fig. 3; Stauffer et al., 1935, p. 638). The Stillwater locality is evidently the one place in Minnesota where drilling has encountered Red Clastics underlain by Keweenawan Oronto sandstone, as indicated by the excessive local thickness of the redbeds and association with Middle Keweenawan diabase. This area is in line with the axis of the Lake Superior syncline, and Keweenawan rocks are here to be expected (figs. 1 and 2).

This interpretation removes a serious anomaly from Meinzer's map (Hall et al., 1911, pl. III) showing the elevation of the "pre-Cambrian": that is, the crystalline floor beneath the sediments in Minnesota. In regarding all redbeds as one unit, (pre-Cambrian in age but mapped with the Paleozoic), Meinzer (Hall et al., 1911, pl. III) is forced to contour a deep 2000-foot hole at Stillwater. The writer's reinterpretation of the composite nature of the redbed section here eliminates this peculiar anomaly.

Ordovician-Jacobsville unconformity.—In the Upper Peninsula of Michigan, another seeming anomaly presents itself at the isolated outlier, Limestone Mountain. Here Middle Ordovician Platteville strata lie in concordant dip not far above layers of Jacobsville sandstone with a short concealed belt intervening (Case and Robinson, 1915; Thwaites, 1943). This extensive unconformity has been interpreted to lie between pre-Cambrian and Paleozoic, to indicate the nondeposition of Cambrian and Lower Ordovician rocks in this region, and thus to establish the pre-Cambrian age of the Jacobsville.

However, an examination of relationships in the eastern part of the Upper Peninsula and southward along the west shore of Lake Michigan reveals that the time of erosion was not between the Bayfield and the Croixan, but between Middle and Lower Ordovician (Thwaites, 1923, 1927, 1934, 1943). Truncation of the pre-Chazyan beds cuts progressively deeper as one goes westward from the upper end of Lake Michigan, and also as one goes northward. The extreme case of depth of pre-Middle Ordovician erosion in Wisconsin-Michigan is at Limestone Mountain where Mohawkian strata rest on the Bayfield.

Lack of Chequamegon equivalent in Minnesota.—The problem of the correlation of Thwaites' Chequamegon formation constitutes another seeming anomaly. To recapitulate, Thwaites (1912) divided the Wisconsin Bayfield group into three formations in descending order as follows:

Chequamegon sandstone	1000 feet
Devils Island sandstone	300 feet
Orienta sandstone	3000 feet
Total	4300 feet

Tyler and Thiel (1940) have shown that the Red Clastics of Minnesota correlate with the Orienta sandstone and the Hinckley correlates with the Devils Island sandstone. But, on top of the Hinckley in Minnesota rests the white Mt. Simon sandstone of Croxian age and upon the Devils Island rests the pre-Croixan, redbed Chequamegon sandstone.

Writers accepting the Wisconsin Bayfield succession at face value (see Thiel, 1940, p. 1516) have regarded this as evidence of a pre-Mt. Simon unconformity involving the loss in Minnesota of 1000 feet of strata. Yet, an abundance of deep well data from that state also seems to indicate that Hinckley-Mt. Simon relations there are clearly gradational.

A critical examination of the evidence on which Thwaites (1912) established his Chequamegon formation reveals a probable resolution of this paradox, namely that Thwaites' Chequamegon brownstone formation is none other than the Port Wing brownstone member of the Orienta formation, repeated by faulting (fig. 8). The contact of the Chequamegon formation with the supposedly underlying Devils Island formation is reported by Thwaites only from the type locality, Devils Island. The beds here that he considers to be Chequamegon, he assigns to the "basal Chequamegon" and describes (1912, p. 38) as follows:

> At the south end of Devils Island, which is entirely surrounded by a rock cliff, the light-colored basal layers of the Chequamegon sandstone are seen. These are interbedded layers similar to the main body of underlying Devils Island sandstone, so that no very sharp line of demarkation can be seen.

The writer suggests that these layers are a part of the Devils Island formation rather than the Chequamegon brownstone and that a fault contact lies off-shore to the south and there separates the Devils Island from the brownstone that forms the southern islands of the Apostle group. Thwaites' detailed description (1912, pp. 34-35) of the "Quarry" or "Brownstone Beds" of the Chequamegon on the mainland is essentially identical with that of the "Port Wing Brownstone" of the Orienta, while the upper or "Washburn Beds," especially those from the well of the Barksdale Powder Works, are described in much the same terms as his "upper member" of the Orienta formation.

Reinterpretations by the writer reduce the total thickness of the Bayfield group from Thwaites' figure of 4300 feet down to a maximum of 2600 feet, mainly through the dropping of the Chequamegon formation. This gives a figure more in accord with the average regional thickness of the subsurface Bayfield.

The Bayfield and the pre-Cambrian peneplain.—There remains one more point of issue which is in the nature of an argument rather than an anomaly. Proponents of a Keweenawan age assignment for the Bayfield stress the fact that the structural elements that affected it and related sandstones were truncated by the pre-Cambrian peneplain. The writer maintains that beyond the areas of Paleozoic cover, there is

no means of determining the age of the present bedrock surface on the crystallines. It may be close to the pre-Cambrian erosion surface, but may be of later origin or origins. Within the Lake Superior region itself, there is evidence not only of pre-Middle Ordovician, but also of pre-Cretaceous and post-Cretaceous, erosion surfaces (Van Hise and Leith, 1911, p. 178, p. 616, p. 625).

The Silurian beds at Limestone Mountain lie below the postulated pre-Cambrian peneplain surface, as do the Jacobsville and Bayfield strata. There is reason to believe that Silurian strata may formerly have extended widely in the Lake Superior Basin and over much if not all of the Wisconsin Arch, and that the Devonian clearly extended over the latter at least in part. It is not plausible to infer that the erosion which removed these thousands of cubic miles of rock stopped completely when the pre-Cambrian bedrock surface was reached.

Supporting the idea that the original pre-Cambrian erosion surface developed before, not after, the deposition of the Bayfield group is Tyler's (1940, p. 1481) conclusion that the Bayfield sediments differ from those of the Oronto group in such a way as to indicate a marked difference in time and a partial difference in source. Tyler states as follows:

> The quartzose character of the Bayfield indicates that these sediments were subjected to more mature weathering than those of the Oronto group, and that the Bayfield group may have been derived from previously existing sediments. The most likely sedimentary source for the Bayfield would be the older Oronto series. Their derivation from this source, however, would necessitate almost complete elimination of feldspar, epidote, and garnet of the Oronto sediments and a large decrease in the quantity of ilmenite. It seems more likely that the Bayfield sediments were derived from the Keweenawan sediments or acidic igneous rocks which did not contain large amounts of epidote or ilmenite and that the region from which the garnet was derived during Oronto time had ceased to contribute sediments to this basin of deposition during Bayfield time.

It seems to the writer that Tyler's evidence does not necessarily indicate a bedrock source low in epidote and ilmenite. Rather it seems to indicate a cycle of deposition independent of and much later than that of the Oronto sedimentation. The latter derived its material from fresh bedrock whereas the Bayfield material seems to have been derived from a mature erosion surface on which the epidote and much of the feldspar was eliminated, and a substantial portion of the ilmenite was altered to leucoxene.

Factors Opposing Keweenawan Age Assignment of Bayfield

Study of the broad field relations has inclined the writer to the opinion that the Bayfield group and its equivalents are more closely related to the Croixan than to the Keweenawan. The present paper has been devoted largely to a review and reduction of the "strong points" which appear to resist a Cambrian assignment for the group. Although a full discussion of the case against a Keweenawan age assignment is not within the scope of this paper, it is appropriate to state that, in the opinion of the writer, the sum of the evidence opposing such an assignment is insuperable. In brief, the following are items of cardinal import to this effect.

1. In places Bayfield equivalents demonstrably rest on pre-Keweenawan strata, as in east-central Minnesota, the Michigan Upper Peninsula, at the east end of Lake

Superior in Ontario, and almost universally in the subsurface; those who would assign a Keweenawan age to the Bayfield must account for the absence by unconformable overlap of from 30,000 to 60,000 feet of pre-Bayfield Keweenawan section. The fact that the 30,000-60,000 feet of earlier strata is so generally missing, with only the "terminal" 2,000-3,000 feet of strata present, fosters the suspicion that we are dealing with two independent sequences.

Whether this absence of 90 to 95 percent of the Keweenawan section at these places be explained as a result of unconformable overlap (Thwaites, 1912; Atwater, 1935, etc.), of faulting (Schwartz, 1949, etc.), or of deposition in postulated grabens (Thwaites, 1943), the minimum local relief involved in any case exceeds the altitude of Mt. Everest (29,002 feet).

The accommodation of the latter concepts becomes most difficult at the west end of Lake Superior. Here, to assign a Keweenawan age to the Fond du Lac, where it rests on the Lower Huronian Thomson Slate complex, it is necessary to account for the disappearance of roughly 55,000 feet of strata (over 10 miles thick) in a narrow gap 10 miles wide, between the North Shore Keweenawan sequence and the South Shore Keweenawan sequence. Either a 55,000 foot mountain ten miles wide, a fault with a 55,000 foot vertical displacement, or pre-Keweenawan grabens 55,000 feet deep must be postulated here to maintain conformability of the Bayfield with the Keweenawan.

If it be necessary to mention additional adverse factors to the Keweenawan age assignment of the Bayfield, there are the following:

2. If, as has been generally credited (Schwartz, 1949, p. 33), the diabasic and basaltic dikes cutting the Huronian complex west of the Hinckley-Red Clastic belt in east-central Minnesota are the dike-roots of eroded Middle Keweenawan flows, then neither the postulate of unconformable overlap nor that of pre-Keweenawan grabens can be maintained; and to maintain the simple fault hypothesis, it is necessary to postulate the removal by erosion of strata considerably in excess of 55,000 feet, west of the fault.

3. Cases where essentially flat-lying strata of Bayfield age surround or lie up-dip from inclined Middle Keweenawan extrusive strata have never been satisfactorily accommodated within a Keweenawan age hypothesis for the Bayfield. Among such cases is Silver Mountain, reported by Irving (1883, p. 202), which is composed of diabase, dipping northwestward 30°, and apparently surrounded by horizontal Jacobsville sandstone. Another which has not been described in detail, is mapped in the Batchawana Bay area of Ontario (Van Hise and Leith, 1911, pl. I).

4. The evidence of the heavy minerals, as reported by Tyler and Thiel (1940), indicates that outstanding differences exist between the suites of the pre-Bayfield and the Bayfield sands. In general the Bayfield suites are more closely comparable with those prevailing in the Mt. Simon and Galesville members of the Croixan Dresbach formation, than with the Keweenawan, and unlike the latter, imply a mature erosion surface at the source.

Interpretation of Bayfield Environment

The writer suggests that the Bayfield sediments are continental de-

posits of Middle and quite possibly also of Early Cambrian age laid down in structural basins formed at or after the close of the Algonkian. The basins in the Lake Superior region were narrow and a consequence of down-faulting along one side, whereas those in southeast Minnesota, in the Lake Michigan region and southward, seem to have been the result of gentle downwarping. Deposition appears at first to have been largely fluviatile (Thwaites, personal communication), passing with increased regional subsidence probably through lacustrine and estuarine conditions (Hinckley and Mt. Simon) with the eventual arrival of marine waters, bringing the Eau Claire faunas to parts of the region.

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THE MT. SIMON SANDSTONE IN NORTHERN ILLINOIS[1]

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Wells in northern Illinois penetrate from 1600 to 2100 feet of upper Cambrian Mt. Simon sandstone between the Eau Claire formation and pre-Cambrian crystallines. In most of the region the sandstone is pure and light colored, but in the vicinity of Boone County all but the uppermost beds are silty, argillaceous, and dark red. The light-colored sandstone long has been correlated with the Mt. Simon formation of northwestern Wisconsin, but recently the red clastics were assigned provisionally to the pre-Cambrian and correlated with the Fond du Lac formation of eastern Minnesota. The present study shows that the red clastics of northern Illinois are a local facies of the light-colored Mt. Simon sandstone. On the basis of differences in grain size, the formation is divisible into seven regionally persistent members. Evidence is presented which suggests that the Mt. Simon sandstone of Minnesota and the upper part of the Mt. Simon at the type locality belong to the Eau Claire formation.

Previous and present studies.—Early subsurface studies in northern Illinois referred all sandstone beneath Eau Claire dolomitic strata to the Mt. Simon, although a possible Keweenawan age for the red clastics at Dixon was suggested (Thwaites, 1923, pp. 534, 553-555). Thwaites' tentative Keweenawan correlation at Dixon was rejected by Knappen (1926, pp. 34-36). In later studies the red clastics of northern Illinois and similar strata in eastern Wisconsin were stated to be of unknown age but were not separated from the Mt. Simon formation (Thwaites, 1931, p. 742; Twenhofel, Raasch and Thwaites, 1935, p. 1693, pl. 151). Possible correlation of the arkosic basal Mt. Simon strata of southern Lee County, Illinois, with the supposedly Keweenawan Hinckley sandstone of eastern Minnesota has been suggested (Payne, 1942, p. 54). Recently the red clastics of northern Illinois were correlated tentatively with the supposedly pre-Cambrian Fond du Lac formation of eastern Minnesota (Bays and others, 1945, p. 1146; Weller and others, 1945), and the regional lithology and thickness of the "Mt. Simon-Fond du Lac (?)" sandstones were summarized (Workman and Bell, 1949, pp. 2041-2043). In the present study all available cuttings from wells in central northern Illinois which penetrated the Mt. Simon and "Fond du Lac (?)" formations were carefully examined, as well as samples from deep borings in part of northeastern Illinois.

Name and definition.—At the type locality the Mt. Simon formation, named from exposures on and near Mt. Simon at Eau Claire, northwestern Wisconsin (Ulrich, 1914, p. 354), consists mainly of coarse-grained, partly conglomeratic, thick-bedded sandstone 234 feet thick, which overlies pre-Cambrian granite and underlies fine-grained thin-bedded *Cedaria*-bearing Eau Claire

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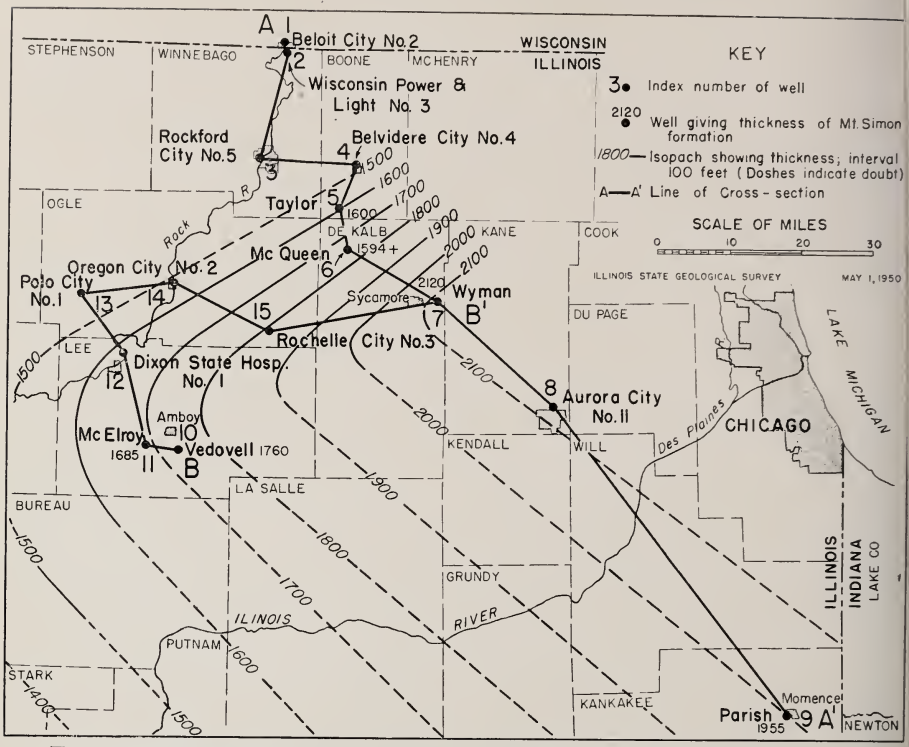

FIG. 1.—Isopach and reference map of the Mt. Simon formation in northern Illinois. (Modified from Workman and Bell, 1948, fig. 4.)

sandstone (Twenhofel, Raasch and Thwaites, 1935, pp. 1693, 1739-1740). In this report the name Mt. Simon is applied to all sandstone between pre-Cambrian crystallines and sediments which are classed as Eau Claire but probably underlie the *Cedaria* zone.

Thickness.—In northern Illinois only four wells (fig. 1, wells 5, 7, 10, 11) have completely penetrated the Mt. Simon sandstone, although two other wells (6, 9) are believed to have passed almost through the formation. The sandstone is thickest in a basin extending from DeKalb to Cook counties in northeastern Illinois and attains a maximum known thickness of 2120 feet in northeastern DeKalb County. From this area it thins rapidly to thicknesses of 400 feet or less in most of the states surrounding Illinois, and lenses out in northeastern Wisconsin and southwestern Ontario (Cohee, 1945, 1948).

Lithology.—In northern Illinois the Mt. Simon sandstone is divisible into a light-colored facies, which constitutes the bulk of the formation in most of the region, and a red facies, which is best developed at Belvidere, Boone County. Much gradation and interfingering characterize the transition zone between the two facies, which in places is less than 6 miles wide (fig. 2, wells 4, 5). Both facies are nonfossiliferous.

Light-colored facies.—The light-colored Mt. Simon facies is white, yellow, or pink to light brown. The sandstone ranges from very fine to very coarse grained and locally is silty. Much of it is conglomeratic, containing quartz granules from 2 to 4 mm. in diameter and quartz peb-

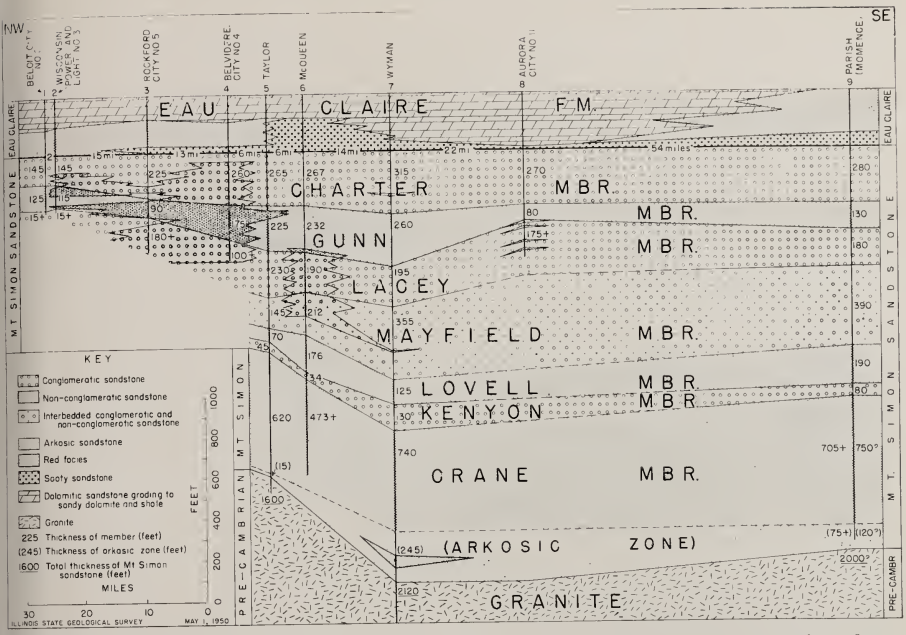

FIG. 2.—Northwest-southeast cross section of the Mt. Simon formation from Beloit, Wisconsin, to Momence, Illinois. (Line A-A′, fig. 1.)

bles from 4 to 8 mm. in diameter. As a whole the sandstone is coarser grained than any other in northern Illinois. Sorting generally is poor, but some well-sorted beds are present. Although the grains range from angular to well rounded, they are chiefly subangular. The granules and pebbles are well rounded. Most of the sandstone is incoherent, but thin layers have been cemented by iron oxide or silica. A zone varying from 15 to 249 feet thick at the base of the formation is arkosic and locally contains biotite and muscovite flakes as well as granite grains and pebbles. Occasional grains of feldspar and granite and very rare gabbro and quartzite pebbles have been observed in higher beds. Thin layers of dark-red or variegated, partly micaceous shale and siltstone occur at different horizons.

Red facies.—Where best developed the red facies is characterized by large amounts of disseminated dark-red hematitic clay and silt and by the presence of relatively thick interbeds of dark-red, partly micaceous, partly sandy shale and siltstone. Where weakly developed, as in southern Lee County, the facies is distinguished mainly by hematitic films on the sand grains.

Subdivision into members. — Throughout northern Illinois the Mt. Simon sandstone consists of a cyclic alternation of relatively fine-grained units and coarse-grained, granule-bearing units (figs. 2, 3). Although to the southeastward and westward granules become scarcer and smaller, and the entire formation grows more silty and finer grained, the sequence still is clearly distinguishable. Some lateral gradation or interfingering may take place along the contacts between the units. The seven major units present are herein regarded as members, and are

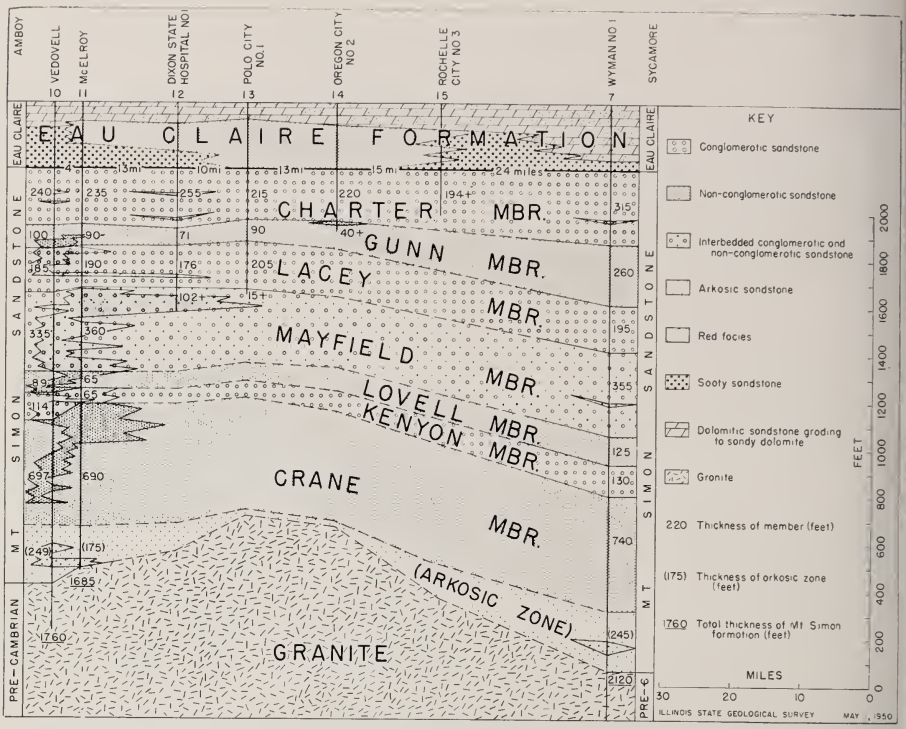

FIG. 3.—Cross section of the Mt. Simon formation from the vicinity of Amboy, Illinois, to the vicinity of Sycamore, Illinois. (Line B-B′, fig. 1.)

named and described in ascending order. The members are made up of numerous subordinate units, many of which extend practically throughout the region.

The type well for the four lower members is Wyman No. 1 (well 7), a cable-tool well in the NE¼ NE¼ SE¼ Sec. 35, T. 41 N., R. 5 E., DeKalb County, Illinois, sample set 1301.[2] The type well for the three upper members is McQueen No. 1 (well 6), a cable-tool well in the SW¼ NE¼ NE¼ Sec. 27, T. 42 N., R. 3 E., DeKalb County, Illinois, sample set 1466.

Crane member.—For the relatively fine-grained basal member of the Mt. Simon formation the name Crane member is proposed. The name is derived from the Crane School, NW¼ NE¼ NW¼ Sec. 22, T. 40 N., R. 5 E. DeKalb County, 4 miles south of the type well. The "type section" consists of samples 387 through 491 in sample set 1301, extending from depths of 3105 to 3845 feet. The member ranges from 620 to 740 feet thick (figs. 2, 3). The grains range from very fine to very coarse, and a few granules are rarely present, but the predominant grades are fine and medium. The lower portion of the member generally is more or less shaly, silty, and arkosic.

Kenyon member.—For the thin conglomeratic sandstone overlying the Crane member the name Kenyon member is proposed. The name is derived from Kenyon school, NE¼ NW¼ NW¼ Sec. 17, T. 40 N., R. 6 E., Kane County, 3¼ miles south-

[2] Number of sample set in subsurface files of Illinois Geological Survey. Most samples in both sets represent five- or ten-foot intervals.

east of the type well. The "type section" consists of samples 367 through 386 in sample set 1301, extending from depths of 2975 to 3105 feet. The member ranges in thickness from 34 to 130 feet. Where less than 80 feet thick, it is composed chiefly of coarse-grained sandstone containing quartz granules, but where thicker it consists of conglomeratic sandstone interbedded with nonconglomeratic layers.

Lovell member.—The succeeding relatively fine-grained unit is here named the Lovell member for Lovell School, SW¼ NW¼ NE¼ Sec. 2, T. 40 N., R. 5 E., DeKalb County, three-quarters of a mile southward from the type well. The "type section" consists of samples 348 through 366 in sample set 1301, extending from depths of 2850 to 2975 feet. In thickness the member varies from 65 to 190 feet. Although grain sizes range from very fine to very coarse, the predominant grade is fine or medium. In the McElroy well (11) the member is partly coarse grained to conglomeratic but is clearly separable from the adjacent coarser-grained units.

Mayfield member.—Overlying the Lovell member is a thick sequence of interbedded conglomeratic and nonconglomeratic sandstones for which the name Mayfield member is proposed. The name is obtained from Mayfield Township, T. 41 N., R. 4 E., DeKalb County, Illinois, 5 miles west of the type well. The "type section" consists of samples 300 through 347 in sample set 1301, extending from depths of 2495 to 2850 feet. The thickness of the member ranges from 145 to 390 feet. The units composed of very coarse-grained to conglomeratic sandstone are from 5 to 125 feet thick; those made up of finer-grained nonconglomeratic sandstone are from 10 to 90 feet thick. In the McElroy well (11) most of the sequence is conglomeratic, but in the Taylor and Parish wells (5, 9) granule beds are very subordinate.

Lacey member.—The fifth Mt. Simon member consists principally of conglomeratic sandstone. It is here named the Lacey member from Lacey School, NW¼ NW¼ NW¼ Sec. 31, T. 42 N., R. 4 E., DeKalb County, 2½ miles east of the type well. The "type section" consists of samples 257 through 278, in sample set 1466, extending from depths of 1880 to 2070 feet. The thickness of the unit ranges from 176 to 230 feet. In most wells a bed or beds of comparatively fine-grained nonconglomeratic sandstone are present in the middle of the member, and in the Parish and McElroy wells (9, 11) interbeds of fine-grained sandstone occur in the lower part of the unit. Red shale layers commonly are more abundant in the Lacey and higher members than in the underlying strata.

Gunn member.—The Lacey member is overlain by a relatively fine-grained unit here named the Gunn member from Gunn School, NW¼ NW¼ NW¼ Sec. 16, T. 42 N., R. 3 E., DeKalb County, 2¾ miles northwest of the type well. The "type section" consists of samples 234 through 256 in sample set 1466, extending from depths of 1648 to 1880 feet. In thickness the member varies from 71 to 260 feet. The grain size ranges from very fine to very coarse, and a few thin beds of granule conglomerate generally are present. However, the grain size is conspicuously finer than in the adjacent members, and in several wells the dominant grade is fine.

Charter member — The coarse-grained to conglomeratic uppermost member of the Mt. Simon formation is here named Charter from Charter Oak School, SE¼ SE¼ SE¼ Sec. 2, T. 42 N., R. 3 E., DeKalb County, 3½ miles north of the type well. The "type section" consists of samples 204 through 233 in sample set 1466, extending from depths of 1381 to 1648 feet. The member ranges from 145 feet to 315 feet thick. In some wells it is composed almost entirely of very fine- to very coarse-grained sandstone which is mainly coarse grained and has one or more thin layers of granule conglomerate. In other wells conglomeratic sandstone makes up most of the member.

Stratigraphic relations.— The Mt. Simon sandstone rests unconformably on a pre-Cambrian basement complex. Where it has been penetrated by wells in northern Illinois, the complex consists of granite with local felsite dikes (Grogan, 1949). The Mt. Simon is overlain by the Eau Claire formation with apparent conformity in both Wisconsin and Illinois (Twenhofel, Raasch and Thwaites, 1935, pp. 1693-1696, 1714-1715).

Correlation.—In Kane County, northeastern Illinois, the basal two-fifths of the Eau Claire formation is composed mainly of sandy dolomite and shale which contains oboloid brachiopods in the lower half (fig. 2). Westward these beds grade laterally into gray, very fine- to coarse-grained sandstone which is given a sooty aspect by encrusting particles of black pyrite (Workman and Bell, 1949, pp. 2043-2049). The sooty sandstone extends into western Illinois and northward to Winnebago County. However, before reaching Beloit, Wisconsin, it passes laterally into light yellow sandstone which is distinguished from the underlying Mt. Simon sandstone by its finer grain-size and the absence of granules. Both the sooty and the yellow sandstone locally contain oboloid brachiopod fragments.

At the type section in Wisconsin the Mt. Simon sandstone shows the following sequence from the base upward: (1) granule-bearing, 3 feet, (2) without granules, 28 feet, (3) granule-bearing, 108 feet, and (4) without granules and containing oboloid brachiopod fragments, 95 feet (Twenhofel, Raasch and Thwaites, 1935, pp. 1739-1740). It is thought most likely that units 1 through 3 correspond, respectively, to the Lacey, Gunn, and Charter members and that unit 4 is equivalent to the basal Eau Claire sandstone of northern Illinois. Definite correlations must await detailed surface and subsurface tracing between Beloit and Eau Claire, Wisconsin. However, if this interpretation is correct, it would appear desirable to include unit 4 of the Mt. Simon type section in the Eau Claire formation because this unit (1) can be distinguished lithologically by the lack of granules, (2) is said to contain marine fossils, in contrast to the barren, presumably fresh-water beds beneath, and (3) grades eastward into dolomite which is entirely similar to the dolomite facies of the Eau Claire formation.

The sandstone termed "Mt. Simon" in eastern Minnesota directly underlies the Eau Claire *Cedaria* zone and in places contains much glauconite and glauconitic shale and siltstone (Atwater and Clement, 1935, pp. 1674-1676), which in Illinois is entirely confined to the Eau Claire formation. Most of this sandstone probably corresponds to the basal Eau Claire sandstone of north-

Table 1. Typical Heavy Mineral Analyses in Percentages

	Anatase	Apatite	Epidote	Garnet	Ilmenite	Leucoxene	Magnetite	Rutile	Titanite	Tourmaline	Zircon	Opaques	Unknown
Eau Claire sooty sandstone; base[1]	6	..	..	....	..	4	....	..	..	31	59	..	....
Mt. Simon light-colored facies; top[2]	1	..	..	....	1	3	....	..	..	27	68	..	....
Mt. Simon light-colored facies; lower[3]	1	..	..	Tr.	..	9	....	..	..	28	62	..	....
Mt. Simon light-colored facies; base[4]	..	..	..	9[a]	..	11	....	..	..	11	69	..	....
Mt. Simon light-colored facies; base[5]	..	..	..	20[a]	..	Tr.	40	..	..	20	20[b]	..	....
Mt. Simon red facies; upper[6]	..	..	..	....	5	1	....	..	..	19	76	..	....
Hinckley sandstone at Sandstone[7]	2	..	3[c]	....	..	18	Tr.[d]	2	..	12	63	..	Tr.
Hinckley sandstone at Net River[8]	1	..	1[c]	....	..	12	44[d]	1	..	13	27	..	Tr.
Fond du Lac sandstone[9]	..	50	..	7	..	A	....	..	..	23	13	4	2
Granite, Taylor No.1[10]	..	15	..	....	..	....	5	..	65	..	15[e]	..	....
Granite, McElroy No. 1[11]	..	C	R	....	C	P	P	P	..	..	C	..	....

[1]Well 7, 1710'-1720' (Herbert, 1944); [2]Charter member, Well 7, 1730'-1750' (Herbert, 1944); [3]Crane member, Well 7, 3790'-3805' (Herbert, 1944); [4]Crane member, Well 7, 3835'-3840' (Herbert, 1944); [5]Crane member, Well 5, 2900'-2905' (Marsden, 1933); [6]Gunn member, Well 5, 1645'-1650' (Herbert, 1944); [7]Tyler and others, 1940, p. 1512, sample P438B; [8]Tyler and others, 1940, p. 1512, sample P423B; [9]Tyler and others, 1940, p. 1508, sample P405; [10]Well 5, 2955'-2960' (Marsden, 1933); [11]Well 11, 3760'-3772' (Winchell, 1932; Grogan, 1949, pp. 98-99); [a]angular; [b]unzoned; [c]includes zoisite; [d]includes ilmenite; [e]zoned; A = abundant but not included in analysis; C = common; P = present; R = rare; Tr = trace.

ern Illinois, although true Mt. Simon strata locally may be included.

Except that it is indurated, the type Hinckley sandstone is exceedingly similar to the light-colored Mt. Simon sandstone of northern Illinois (Atwater and Clement, 1935, pp. 1669-1672, 1680; Stauffer and Thiel, 1941, pp. 15-23). The heavy mineral suites are fairly similar (table 1), although the Hinckley generally has higher proportions of magnetite, ilmenite and leucoxene and lower proportions of tourmaline and zircon. Feldspar is rare in the Hinckley, rare in the Mt. Simon of Illinois, except in the basal arkosic zone, and present only in very low percentages in the Mt. Simon of the type area (Stauffer and Thiel, 1941, p. 18, table 1).

The contact between the Hinckley and the underlying red Fond du Lac formation is gradational (Stauffer and Thiel, 1941, p. 17). The chief differences between the two sandstones are (1) the higher iron-oxide, shale, and feldspar content of the Fond du Lac, and (2) the presence of apatite and garnet and a higher percentage of leucoxene in the Fond du Lac heavy mineral suite. It seems most likely that the Fond du Lac is an arkosic, impure, basal facies of the Hinckley formation, the heavy minerals of which were derived from sources that later became buried. An analogous situation occurs in northern Illinois where the heavy mineral suite of basal Mt. Simon strata locally differs from that of the higher beds (table 1).

Raasch (1950) has presented evidence for the Cambrian age of the Hinckley and Fond du Lac formations. The writer tentatively correlates the entire Hinckley-Fond du

Lac sequence with the Mt. Simon sandstone of northern Illinois. Further study is needed to determine whether it has the same succession of conglomeratic and finer-grained members. Since no lithologic or physical evidence has been found for a formational break in the northern Illinois sequence, the name Mt. Simon is applied throughout.

The Mt. Simon sandstone of northern Illinois also is considered equivalent to the Bayfield and Jacobsville sandstones of the south shore of Lake Superior (Raasch, 1950) and to the Lamotte sandstone of eastern Missouri (Workman and Bell, 1948, pp. 2041-2043, figs. 2, 3).

Historical Interpretations

In Wisconsin the pre-Cambrian surface appears to have been a peneplain interrupted by monadnocks. The sparse data provided by wells in northern Illinois also suggest that the basement surface had slight relief.

It has been suggested that the Mt. Simon sandstone was rapidly deposited in a shallow, fresh- or brackish-water inland sea (Twenhofel, Raasch and Thwaites, 1935, pp. 1714-1715). The fact that the sandstone seems to be thickest in northern Illinois instead of thickening southward like most other Paleozoic formations supports this concept. Rapid sinking of the basement must have accompanied deposition to produce by far the thickest formation in Illinois. Periodic uplifts of the surrounding borderlands sent influxes of pebbly sand into the sea. Nonconglomeratic sand was laid down during intervals of crustal quiescence.

Probably the Mt. Simon quartz sand was derived mainly from weathered granites and gneisses to the north and was transported to the sea by streams. The general lack of rounding, frosting, and sorting indicates that the sand was not greatly reworked before deposition. The differences between the heavy mineral suites of the Mt. Simon and the underlying granite in northern Illinois (table 1) and the partial rounding of most Mt. Simon heavy minerals show that the bulk of the basal sand was not derived from the granite of that region. However, erosion of the granite contributed angular feldspar fragments to the initial sediments. The arkosic zone probably is thickest in the areas of greatest basement relief, as adjacent to monadnocks. That a minor part of the basement in northern Illinois or nearby areas consisted of schist is demonstrated by the presence of angular garnets in the heavy mineral suite of basal Mt. Simon strata in the Taylor and Wyman wells (5, 7) and by the occurrence of small schist fragments in the Mt. Simon of the Parish well (9).

In an area northward from Illinois a red clayey mantle probably developed on granitic rocks under conditions of low relief and a warm, humid climate, such as prevail at present in the southern Appalachian piedmont. It is believed that the Mt. Simon red facies was deposited off the mouth of a river which drained this area and discharged into the sea north of Belvidere, Boone County. The similarities in the heavy minerals of the red and light-colored facies suggest that both were derived from the same granitic terrane. Enlargement of the sea just prior to the marine invasion of Eau Claire time (Twenhofel, Raasch, and Thwaites, 1935, pp. 1714-1715) is reflected in abrupt overlap of the red sediments by a

relatively small thickness of white sandstone. Persistence of a drainage system which furnished red clastics is suggested by the recurrence of a similar red facies in the Franconia and uppermost Eau Claire strata of Boone County.

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PETROLOGY OF THE BASAL HIGH-PURITY BED OF THE BURLINGTON LIMESTONE*

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A high-purity, virtually chert-free limestone occurring near the base of the Burlington limestone in western Illinois is being mined or quarried at Quincy, Gladstone, and Pearl. This article presents the results of an initial study of the petrology of this 10 to 25-foot unit. Twenty thin sections, perpendicular to the bedding, were prepared from specimens collected at the localities mentioned, especially the Quincy area.

The specimens are mixtures, in varying proportions, of five principal components: (1) large fragments of crinoid plates and stem segments, which are inclusion-rich, unit-extinguishing sheets of calcite; (2) secondary white calcite, deposited in optical continuity upon the detrital fragments; (3) moderate to fine-grained fossil detritus, including fragments of bryozoa, pelecypods, brachiopods, and smaller bits of crinoid plates and stem segments; (4) very fine-grained dark gray interstitial calcite; and (5) small unit-extinguishing rhombs of dolomite. Coarsely crystalline specimens of the limestone consist chiefly of the secondarily enlarged pieces of crinoidal calcite. Finely crystalline varieties show pronounced banding in thin section, with different bands varying both in components and in particle size. The banding, in general, parallels the bedding planes of the rock, but in detail it may be contorted or lenticular at some places. Dolomite rhombs occur mostly in the fine-grained interstitial carbonate component, and are thus commonest in fine-grained varieties of the rock.

History of Events

The history suggested by the thin-section study is indicated in table I. In the first stage crinoid fragments were deposited with a mud containing abundant fossil fragments. The interstitial material between the crinoid fragments contains far too much debris and is too fine grained to have crystallized

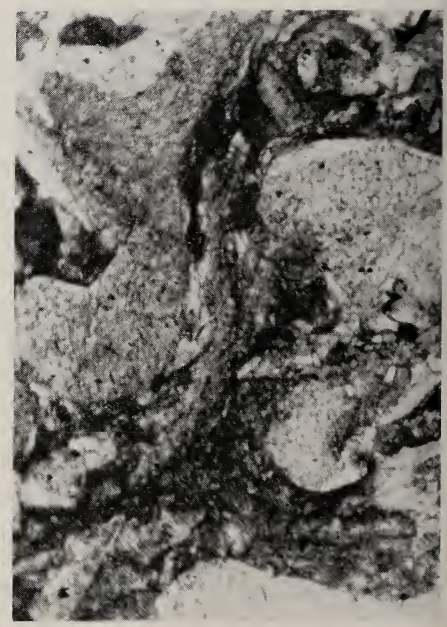

Fig. 1.—Subparallel alignment of smaller detrital fragments. Parallel nicols, 20 X.

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from circulating water. A streakiness in the fine-grained portion of the interstitial material arises in part from the presence of elongate, laminated pieces of pelecypod shells, and, almost certainly, in part from the original deposition of elongate pieces of fossil detritus in planes essentially parallel with the ocean floor. However, a "streamline" effect seen in some places (fig. 1), in which sub-parallel particles diverge to go around larger particles, suggests local flowage during compaction which accentuated the other two features.

Secondary white calcite, free of inclusions, was deposited in optical

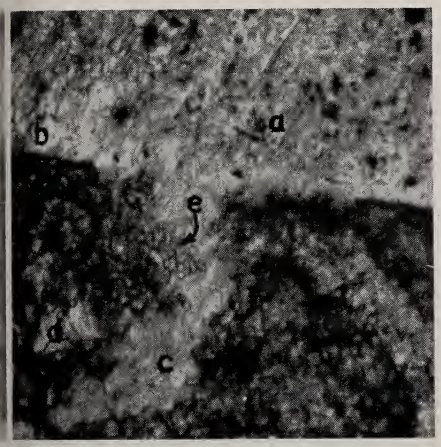

Fig. 2.—Portion of crinoid stem segment (a), secondary calcite rim (b), vein-like extension of rim (c), "island" (d), and fine-grained aggregate interpreted as result of late partial destruction of vein-like extension (e). Parallel nicols, 135 X.

continuity upon the large, inclusion-rich, unit-extinguishing sheets of calcite in crinoid plates. Less commonly (fig. 2) it forms vein-like extensions into fine-grained interstitial calcite. Secondary calcite from two or more nearby fragments commonly meets along a curving contact, giving rise to local areas in the rock that are coarsely crystalline aggregates (fig. 3). The deposition of secondary white calcite has been so extensive in some places as to cut across and isolate areas of streaked interstitial material. In these areas rearrangement of particles by flowage would have been unlikely without some disruption of the secondary calcite, which has not been seen;

Fig. 3.—Secondary calcite rims on adjacent grains grown together to form a coarse-grained rock, with small remnant areas of dark fine-grained interstitial calcite. Parallel nicols, 20 X.

hence deposition of secondary calcite is placed after compaction and flowage.

The margins of many of the secondarily enlarged calcite sheets in contact with interstitial carbonate are ragged, and the question arises as to which calcite is replacing the other. The fact that there are outlying islands of secondary white calcite in optical continuity with larger areas (fig. 2) suggests that the fine-grained interstitial calcite is the active replacing agent, but the "islands" may actually be continuous in the third dimension with the main mass. Further evidence is furnished by a few fine-grained aggregates of

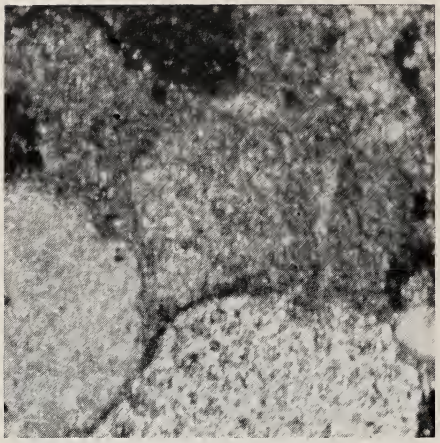

Fig. 4.—"Ghost" composed of small grains in center of picture; two unit-extinguishing sheets of inclusion-rich crinoid calcite below. Crossed nicols, 65 X.

clear white calcite adjoining the secondary calcite projections, which are best explained as partially resorbed marginal portions of the projections.

"Ghosts" in the interstitial calcite show outlines of larger calcite particles that are now represented by an aggregate of small grains (fig. 4). Although the "ghosts" were not necessarily formed at the same time as the partial solution of the secondary carbonate rims, their presence does indicate that coarsely crystalline calcite has at one time during the history of the rock undergone alteration to a fine-grained aggregate. Both these solution effects can be placed, with considerable assurance, later than deposition of secondary calcite because cores of organic calcite lying within the secondary calcite rims are smooth and uncorroded.

The dolomite rhombs have been identified by Debye powder X-ray diagrams; in the absence of evidence to the contrary, they are assumed to be of a single age and of essentially constant composition. They are later than the postulated compaction, for they cut across "streamline" textures. They are earlier than at least part of the period of replacement of coarsely crystalline calcite, for many thin sections contain rhombs that have been partially dissolved (fig. 5). The prominence of this solution varies considerably within limited stratigraphic thicknesses. The age of the rhombs with regard to the deposition of secondary calcite is uncertain. A few rhombs project into the secondary calcite, but it is not yet known whether the rhombs have replaced the coarsely crystalline material, or the latter has replaced the material around the rhombs but left them untouched.

Minor Components

Uncommon small irregular areas of low birefringence, moderate index, and non-uniform extinction are found within large unit-extinguishing crinoid plates (fig. 6). They are not potash feldspar, since a sodium cobaltinitrite staining test gave neg-

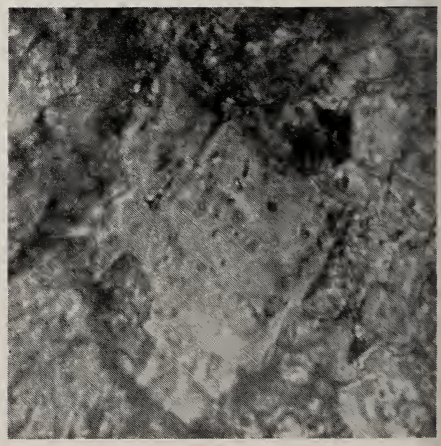

Fig. 5.—Dolomite rhomb partially dissolved along left-hand margin. Parallel nicols, 280 X.

Table I. History of Events

1. Deposition of detritus from crinoids; interstices between larger crinoid fragments filled with mixture of lime mud, glauconite granules, and fossil detritus.		
2. Compaction locally accentuates parallelism of elongate particles in interstitial material.		
3. Deposition of secondary calcite in optical continuity upon crinoid fragments		Formation of dolomite rhombs.
Some crinoid fragments in interstices reduced to fine-grained aggregates.	4. Secondary calcite partially replaced by fine-grained aggregate, perhaps contemporaneously with solution of dolomite rhombs and with replacement of small detrital fragments.	Partial solution of dolomite rhombs.

Fig. 6.—Aggregate of grains which may be secondary silica, lower center near margin of crinoid stem segment. Crossed nicols, 65 X.

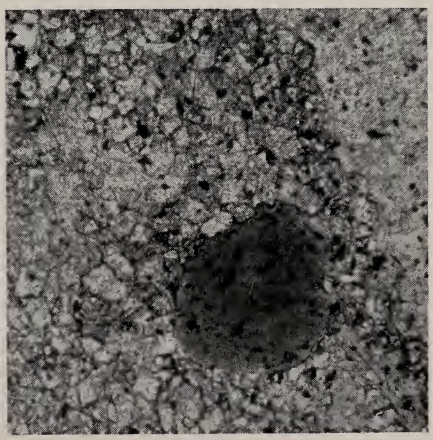

Fig. 7.—Glauconite grain in dolomite-rich Burlington limestone. Parallel nicols, 65 X.

ative results, but they may be secondary silica.

Rounded areas of a greenish material (fig. 7) give an X-ray pattern and a differential thermal curve which correspond in general with those expectable for glauconite, but this identification will not be meaningful until glauconite and related layer-lattice minerals have undergone much more study as mineral types. A basal spacing of 10 Ångström units was noted, but other critical X-ray reflections were obscured by lines of quartz, which occurred even in the 1-micron fraction of the "glauconite." These rounded greenish areas do not cut across other structures, and are most likely detrital in origin. Many dolomite crystals end abruptly against the "glauconite," without completing the rhomb shape. In some cases they penetrate into cracks, but no actual replacement of "glauconite" by either calcite or dolomite has been noted.

METAMORPHIC DEVELOPMENT OF THE EASTERN PART OF THE CRAWFORD NOTCH QUADRANGLE, NEW HAMPSHIRE

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The Crawford Notch quadrangle is situated in the White Mountains of central New Hampshire. The rocks in the quadrangle are of two major types: (1) metamorphic and plutonic rocks of Devonian age and (2) mildly alkaline igneous rocks of probable Mississippian age. This paper is concerned with the evolution of the Devonian metamorphic and plutonic rocks.

Lithology

Terminology.—The term "granitic" material is used in a megascopic descriptive sense to refer to light-colored granitic-looking rock contained in gneiss and schist. The terms granite, quartz monzonite, granodiorite, and quartz diorite are used purely in a descriptive sense to designate essentially massive granular rocks which have mineralogic compositions according to the classification of Johannsen (1939). None of these terms have genetic connotations.

General features.—The Devonian rocks consist mainly of gneiss and schist of the Littleton formation which contain about 50 percent of intermixed "granitic" material. A small amount of fine-grained gneiss and lime-silicate granulite is locally interbedded in the gneiss and schist.

Also in the area are three bodies of quartz monzonite each approximately two miles across.

Littleton formation.—The bulk of the Littleton formation consists of medium-grained biotite-muscovite gneiss which contains approximately an equal amount of "granitic" material in lenses, bands, and small irregular bodies. Locally, the amount of "granitic" material ranges from a few percent to almost 90 percent. It is predominantly concordant in rocks which contain less than 50 percent. Much is discordant in rocks which contain more than 50 percent. The mineralogic composition of the average gneiss is given in column 1 of table 1. The mineralogic composition of the "granitic" material is like that of column 3 of table 1.

Six areas of schist which range from approximately one-half to two square miles occur in the gneiss in the northeastern quarter of the quadrangle. The typical schist is medium-grained muscovite-biotite-chlorite schist and is spangled with porphyryblasts of muscovite approximately 0.5 to 1 cm. across. Most of the schist contains approximately 50 percent "granitic" material similar to that in the gneiss. In many areas the schist occurs as fragments ranging from an inch to many feet across. A body of schist in the northeast corner of the quadrangle and a small projection of schist from a large area in the Mt. Washington quadrangle to the north are the only large areas of schist which contain

Table 1.—Approximate Modes of Metamorphic and Plutonic Rocks, Crawford Notch Quadrangle, N. H.

	1	2	3	4	5	6	7	8
Biotite	20	10	..	30	..	..	30	3
Muscovite	20	40	20	20	..	..	..	2
Quartz	35	15	50	20	..	25	30	30
Plagioclase	20	15	25	20	30	25	20	33
Perthite	..	..	5	..	..	..	..	30
Chlorite	5	20	..	10	..	..	..	2
Sillimanite	tr	tr	..	..	..	..	..	tr
"Orthoclase"	..	..	..	..	40	30	..	..
Actinolite	..	..	..	..	20	..	10	..
Diopside	..	..	..	..	10	20	..	..
Garnet	..	..	..	..	..	..	10	..
Percent of anorthite in plagioclase	20	20	20	20	50	60	80	20

1. Average mode of gneiss.
2. Average mode of schist.
3. Average mode of "granitic" material in schist.
4. Fine-grained thin-bedded gneiss, railroad cut, Crawford Notch.
5. Actinolite-diopside granulite, central part of Crawford Notch quadrangle.
6. Diopside-actionolite granulite, central part of Crawford Notch quadrangle.
7. Biotite-actinolite-garnet granulite, east edge of Crawford Notch quadrangle.
8. Average mode of quartz monzonite.

practically no "granitic" material. An average mode of the schist is given in column 2 of table 1. An average mode of "granitic" material in schist is given in column 3 in table 1.

Lenses and groups of beds of fine-grained gneiss and lime-silicate granulite which range from a few inches to tens of feet thick are scattered through the gneiss and schist. The bedding is almost undeformed in most places, and in many places resembles the bedding of varved clay. The composition differs greatly in different beds. Some of the most typical compositions are shown in columns 4 to 7 in table 1. Much of the fine-grained gneiss and lime-silicate granulite occurs in broken fragments and slabs, ranging from a few inches to tens of feet across, in gneiss and schist containing 50 percent "granitic" material.

Quartz monzonite.—Rocks included under the term quartz monzonite actually range in composition from sodic quartz diorite to granite. The structure ranges from gneissose to massive. The average rock is slightly foliated biotite-muscovite quartz monzonite. An average mode is given in column 8 of table 1.

Much of the quartz monzonite occurs in dikes and irregular small bodies in the Littleton formation. It is similar in appearance to the predominantly concordant "granitic" material in the Littleton formation. The distinction between the quartz monzonite and the "granitic" material is arbitrary and is based chiefly on structural relations. The quartz monzonite is predominantly discordant and occurs in larger bodies than the "granitic" material.

The quartz monzonite occurs in only three bodies large enough to map geologically. The contacts are gradational into the gneiss and schist of the Littleton formation. An interesting relationship exists between the size and composition of the bodies of quartz monzonite. In general, the small bodies are quartz dioritic or granodioritic in composition, whereas the larger bodies approach a true granitic composition.

Structure

Only a brief and generalized account will be given of the structural features. The rocks are greatly and irregularly contorted and the detailed structural relations are not easily discernable because of their

TABLE 2.—CHEMICAL ANALYSES OF DEVONIAN METAMORPHIC AND PLUTONIC ROCKS IN NEW HAMPSHIRE

	1	2	3	4	5	6	7	8
SiO_2	58.92	58.14	61.40	56.23	66.68	62.87	63.5	68.8
TiO_2	0.93	0.65	0.92	1.11	0.87	0.92	0.9	0.4
Al_2O_3	18.55	21.00	19.04	23.15	18.17	17.43	17.6	15.9
Fe_2O_3	0.94	0.33	0.63	1.17	0.90	0.55	0.9	0.5
FeO	6.63	6.32	6.90	6.94	4.98	6.67	6.5	4.0
MnO	0.08	0.06	0.07	0.12	Tr.	0.23	Tr.	Tr.
MgO	3.24	3.41	2.10	2.21	1.42	2.71	2.5	1.2
CaO	0.48	0.32	0.90	0.26	0.76	0.59	0.7	1.5
Na_2O	1.49	1.10	1.30	1.14	0.74	1.71	1.7	2.9
K_2O	3.74	3.85	3.74	4.53	2.89	4.08	4.0	4.2
H_2O+	3.90	4.47	2.89	2.75	1.75	2.10	2.0	0.6
H_2O-	0.11	n.d.	0.06	0.09	0.40	0.08		
CO_2	0.25	0.00	0.01	0.01	0.00	0.02		
P_2O_5	0.14	0.00	0.08	0.18	Tr.	0.11		
S	0.17	0.09	0.08	0.02	0.05	0.04		
ZrO_2	n.d.	0.04	n.d.	n.d.	n.d.	n.d.		
C	n.d.	n.d.	n.d.	n.d.	0.29	n.d.		
O–S corr.	–0.06	.....	–0.03	.....	.....	–0.02		
Total	99.51	99.78	100.09	99.90	99.90	100.09	100.0	100.0

1. Slate, Littleton formation, Littleton quadrangle (Billings, 1941, p. 902).
2. Slate, Littleton formation, Littleton quadrangle (Billings, 1937, p. 556).
3. Fine-grained pseudo-andalusite schist, Littleton formation, high-grade zone, Mt. Washington quadrangle (Billings, 1941, p. 902).
4. Coarse pseudo-andalusite schist, Littleton formation, high-grade zone, Mt. Washington quadrangle (Billings, 1941, p. 902).
5. Sillimanite schist, Littleton formation, high-grade zone, Franconia quadrangle (Billings, 1938).
6. Banded gneiss, composed of approximately equal amounts of dark and light bands, Littleton formation, Mt. Washington quadrangle (Billings, 1941, p. 902).
7. Approximate average composition of gneiss and schist in the Littleton formation, Crawford Notch quadrangle. Calculated from the average mode.
8. Approximate average composition of quartz monzonite in the Crawford Notch quadrangle. Calculated from the average mode.

complexity and irregularity, the intense metamorphism, and the lack of outcrops in many critical places. Most of the major folds probably trend approximately northeast-southwest. Minor folds rarely show systematic relations to one another or to major folds. Irregular minor folds are particularly conspicuous in areas of gneiss and schist which contain abundant "granitic" material.

Much of the quartz monzonite occurs in irregular discordant bodies which are less than 50 feet across. It is so abundant in most of the gneiss and schist that it cuts these highly contorted rocks into extremely coarse breccias with blocks ranging from an inch to several hundred feet across.

The large bodies of quartz monzonite are irregularly shaped, essentially cross-cutting and gradational into the surrounding gneiss and schist. The foliation of the quartz monzonite and the foliation of the abundant bands of gneiss and schist within the quartz monzonite are essentially parallel to that of the surrounding gneiss and schist.

METAMORPHISM

Original nature of the Littleton formation. — Local preservation of sedimentary bedding, the chemical composition, and correlation with rocks of unmistakable sedimentary origin in the Littleton-Moosilauke area indicate that the gneiss, schist,

fine-grained gneiss and lime-silicate granulite originally were sediments. Lithologic correlation and comparison of the chemical composition of the high-grade metamorphic rocks in the Crawford Notch area with those of the low-grade shales and slates in the Littleton quadrangle indicate that the original sediments in the Crawford Notch region were predominantly shales and sandy shales. Analyses and calculated analyses of such rocks may be compared in table 2. The mineralogic compositions of the fine-grained gneiss and lime-silicate granulite (table 1) indicate that small amounts of impure sandstone, arkose, and dolomite were interbedded with the shale.

Stage of recrystallization. — The first major change during metamorphism of the shaly sediments probably was simple recrystallization with essentially no differential movement of chemical constituents over distances greater than a few millimeters. The resulting products were schist and gneiss which probably contained no intermixed "granitic" material. Although most of the recrystallized rocks were subsequently greatly modified, local remnants have survived. The rocks were recrystallized in response to increase in temperature and pressure, particularly differential pressure. The generally coarse grain-size and the widespread occurrence of sillimanite indicate that high-grade conditions were reached throughout most of the quadrangle.

Stage of reconstitution.—Throughout most of the quadrangle simple recrystallization was followed by a stage of reconstitution which involved widespread movement of material. The resulting product was gneiss and schist containing abundant intermixed "granitic" material. Movement of material is clearly indicated by the occurrence of all stages of destruction of the original sedimentary features which survived the stage of recrystallization. Furthermore, all steps in the regrouping of constituents into light and dark bands can be observed. Although movement of material was widespread the similarity in composition (table 2) of the reconstituted rocks and the original and recrystallized rocks indicates that the distance of movement of the individual constituents probably was less than a few feet or tens of feet.

The reconstitution of the schist and gneiss into rocks with segregated dark and light bands is believed to have taken place by a process of metamorphic differentiation essentially like that proposed by Eskola (1932). The process depends chiefly upon the greater solubility of the light-colored minerals and a tendency for the constituents of such minerals to collect and crystallize along the foliation. Metamorphic differentiation was favored by continuation and increase in temperature conditions from the preceding stage of recrystallization. The movement of constituents in metamorphic differentiation probably was chiefly in solution by flow and diffusion through inter-granular and larger spaces. Solid diffusion through crystal structures probably was not important because the larger atoms or ions such as K, Na, and Ca apparently moved as easily as the smaller Fe, Mg, and Al atoms.

Stage of metasomatism.—A stage involving differential movement of material followed the stage of reconstitution and resulted in the formation of the typically discordant quartz monzonite. The stages prob-

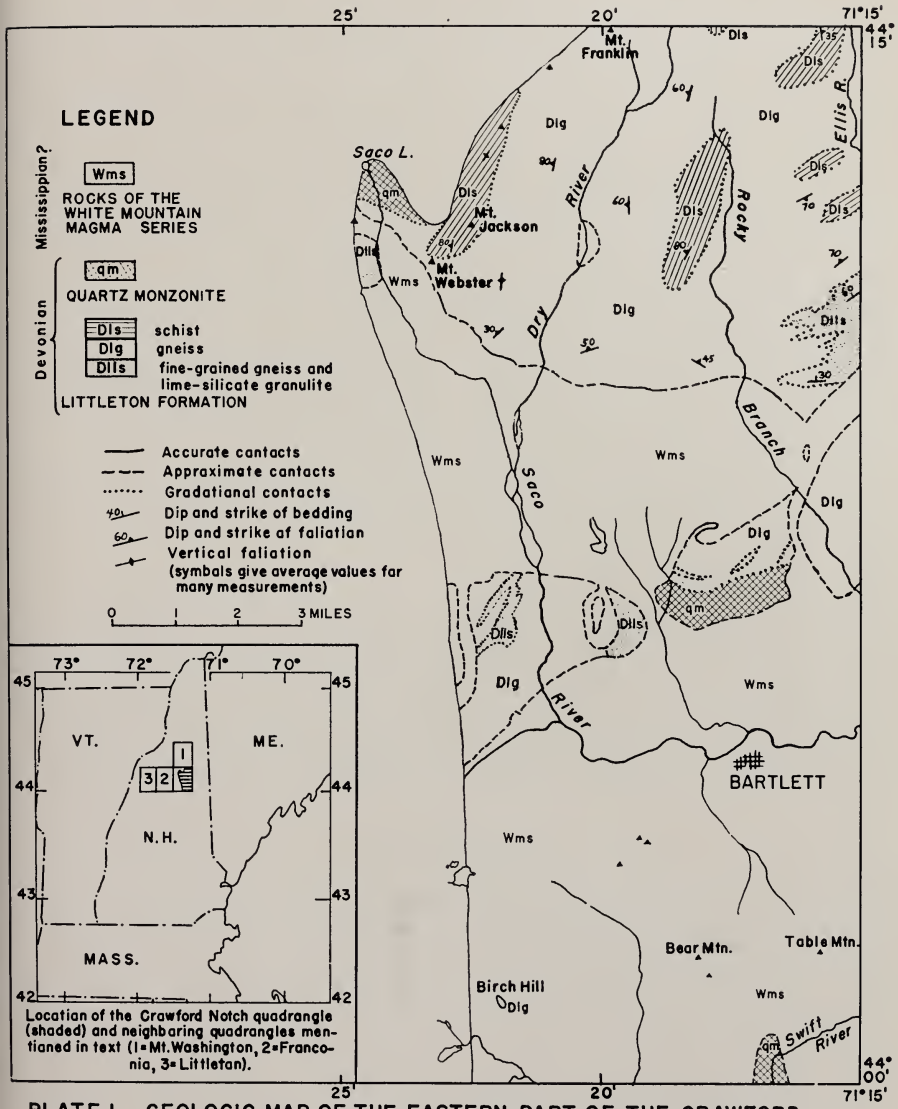

PLATE I. GEOLOGIC MAP OF THE EASTERN PART OF THE CRAWFORD NOTCH QUADRANGLE, N.H.

ably were transitional because complete gradation exists between the composition and structural occurrence of the "granitic" material in gneiss and schist and those of the quartz monzonite.

Comparison of the composition of the average quartz monzonite with that of the older rocks (table 2) indicates an introduction of CaO, Na_2O, K_2O, and SiO_2 and a removal of FeO, MgO, and Al_2O_3. The differential movement of material causing the changes in composition probably was aided by widespread fracturing of the previously formed rocks which allowed easier movement of material over distances of many feet. The formation of the large bodies of quartz monzonite may have been favored by localized extreme fracturing. Intermediate steps in the formation of the larger bodies are apparent in many places.

Metasomatism or intrusion of melts appear to be the major alternative mechanisms for the production of the quartz monzonite. Metasomatism by solutions contributing CaO, Na_2O, K_2O and SiO_2 and removing FeO, MgO, and Al_2O_3 is believed to be the most probable mechanism because of abundant evidence of replacement and because of the large amount of heat necessary to produce a silicate melt.

Retrograde stage.—The preceding stages produced under conditions of increasing temperature and pressure were followed in many places by changes apparently in response to conditions of decreasing intensity. The changes were similar to those in many other areas. The most conspicuous were chloritization of biotite and sericitization of sillimanite, andalusite, and plagioclase.

Acknowledgment

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PREGLACIAL GRAVELS IN HENRY COUNTY, ILLINOIS

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Preglacial deposits of iron-stained chert gravels underlie the glacial drift at a number of localities in the Mississippi Valley region (fig. 1). These gravels, which generally have been referred to the late Tertiary Lafayette formation, are significant in recording geologic events during closing stages of the lost interval between Pennsylvanian bedrock deposition and Pleistocene glaciation. It is the purpose of the present paper to describe gravels from a new locality in western Illinois and to indicate their bearing on late Tertiary geomorphic events.

Description

The gravels are exposed in a highway cut (fig. 2) 7 miles northwest of Kewanee, Henry County, Illinois (400 feet N. of S. W. cor. sec. 3, T. 15 N., R. 4 E.), in the section described below.

The Tertiary gravels differ from all known glacial deposits in the area in their degree of surface alteration, polish, and uniform siliceous composition. Their lithology, based on a count of 120 pebbles, is 79% chert, 18% vein quartz, and 3% quartzite. Crystalline rocks and local bedrock appear to be completely absent. Nearly all the cherts have a yellow-brown iron oxide patina 1-3 mm. thick which is as hard and dense as the interior of the pebbles. A few cherts have a whitish surface alteration and the quartz and quartzite pebbles show surficial iron-staining.

	Thickness		*Depth*	
	Ft.	*In.*	*Ft.*	*In.*
Wisconsin drift				
Peorian loess				
Soil, gray	0	6	0	6
Loess, tan, mottled gray, non-calcareous	3	0	3	6
Loess, tan to gray, calcareous, concretions	2	0	5	6
Farmdale loess				
Silt, carbonaceous, peaty, gray with black humus streaks, abundant gastropods in pockets, non-calcareous	0	4	5	10
Loess, maroon-brown, compact, non-calcareous, gastropods	2	0	7	10
Illinoian drift				
Gumbotil, gray-brown, siliceous residuals, non-calcareous except for some secondary enrichment at top	2	6	10	4
Till, yellow-brown, abundant chert mixed with other rock types, non-calcareous	1	0	11	4
Sand, brown, in local channel	1	0	12	4
Tertiary gravel				
Gravel, 80% brown fossiliferous chert, iron oxide patination, rounded to angular, average 1 to 2 inches, irregular basal contact	3	0	15	4
Pennsylvanian (Canton) shale				
Shale, yellow-buff, micaceous, clayey, broken down by weathering	3	6	18	10
Shale, buff-gray, stratified	5	0	23	10

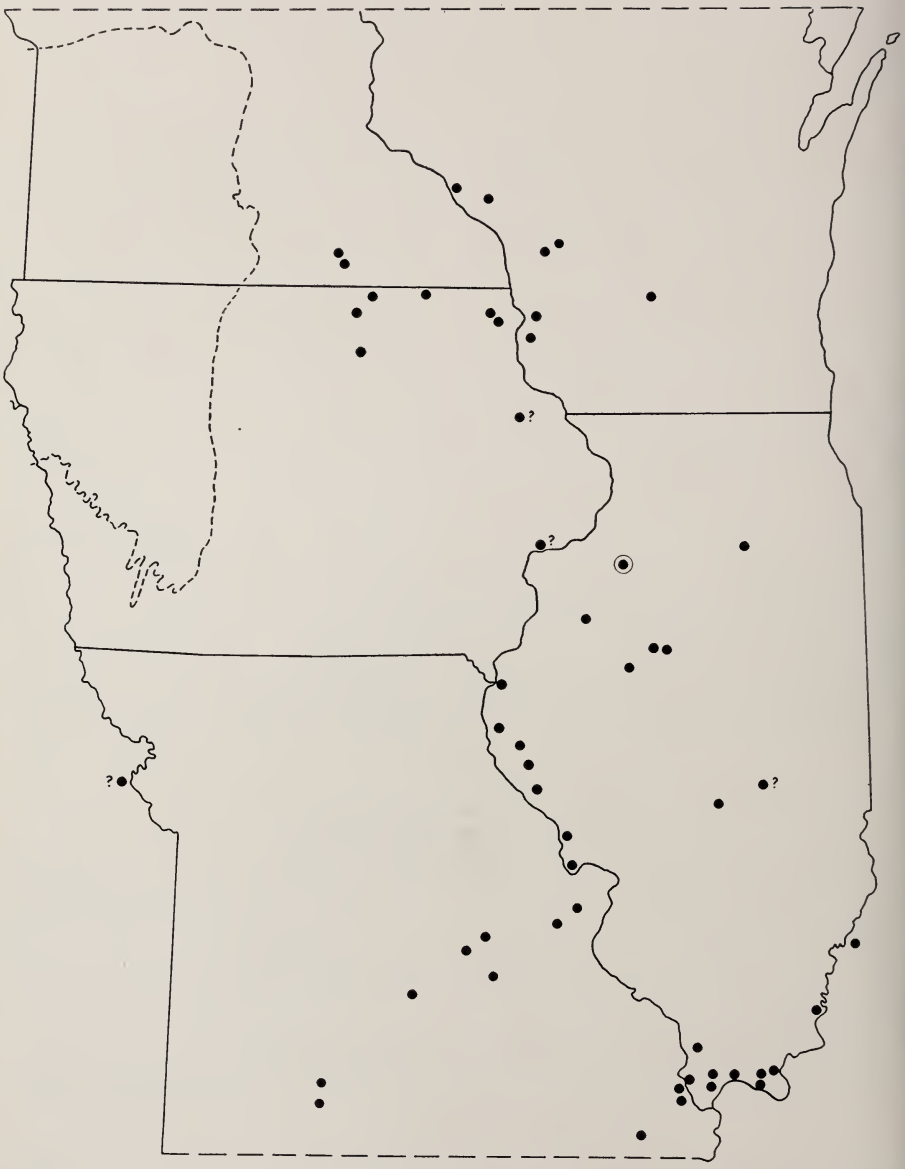

FIG. 1.—Occurrences of preglacial Lafayette-type gravels in the Mississippi Valley region. The Henry County locality is circled. The eastern boundary of Cretaceous deposits in Iowa and Minnesota is shown by a dashed line. Based on references cited and field notes on south-central Missouri by J H. Bretz.

The brown chert pebbles, which make up 70% of the deposit, contain fossil corals, crinoids, and brachiopods of Lower and Middle Silurian age (Heinz Lowenstam, personal communication, 1950).

The pebbles range in diameter from a fraction of an inch to 7 inches, the average being between 1 and 2 inches. The brown chert pebbles are larger than the other types and there is a distinct variation in average size from one part of the exposure to another. All the cherts are angular. Many pebbles are broken rounds, some are chipped, and a few have percussion markings. The gravels are unconsolidated, and the matrix, if it was ever present, has been removed by weathering.

The basal contact of the gravel is irregular and slopes to the south and west. Since the low ridge crest on which the gravels occur slopes northeast, it is clear that the gravels were laid down on a land surface unrelated to the present topography.

The upper part of the Canton shale underlying the gravels is oxidized and mechanically weathered to a depth of about 3 feet. Under the microscope the weathered shale is seen to differ from the unaltered shale in its lack of stratification, disaggregation into silt and clay-size particles, oxidation, and content of limonitic aggregates.

The gravels occur at an elevation of 730 feet near the northern margin of a buried bedrock upland, which locally has an average elevation of about 750 feet and lies 450 feet above the buried bedrock valley of the ancient Mississippi river some 15 miles to the north. The upland surface has been correlated with the Lancaster peneplain of the Driftless Area (fig. 1) (Horberg, 1946, pp. 186-188.) Farther south in western and southern Illinois nearly all occurrences of preglacial gravel are on this surface or equivalent surfaces correlated with the Ozark and Calhoun peneplains.

Correlation and Age

Although it is probable that similar deposits of different ages are represented and that some gravels are reworked, the deposits in the Mississippi Valley region can be correlated in a general way by lithology and physiographic position. On this basis the gravels in Henry County appear to be equivalent with the Windrow formation of Wisconsin, Iowa, and Minnesota (Thwaites and Twenhofel, 1921); the "Tertiary" gravels of LaSalle County (Willman, 1942, pp. 140-141), Peoria County (Udden, 1912, p. 50) and other counties in western Illinois (Worthen, 1866, p. 330; 1870, p. 37; Bannister, 1870, p. 179; Salisbury, 1891, pp. 252-253); the Grover gravel of the St. Louis region (Salisbury, 1892, pp. 183-186; Rubey, 1931); and the Lafayette gravel of southern Illinois and southeastern Missouri (Lamar and Sutton, 1930, pp. 857-859). Correlation with the Rockville conglomerate at Dyersville, Iowa (McGee, 1891, p. 304) and the Pine Creek conglomerate near Muscatine, Iowa (Udden, 1899) is questionable because of the high proportion of crystalline rocks in these deposits. Also it is uncertain whether the two occurrences at lower elevations within the area of the Central Illinois peneplain (fig. 1) are primary or reworked.

A Tertiary age for the gravels farther south is evidenced by their presence on truncated Eocene formations at the head of the Gulf em-

Fig. 2.—Highway cut 7 miles northwest of Kewanee, Illinois. Wp—Peorian loess; Wf—Farmdale loess; It—Illinoian gumbotil and till; Tg—Tertiary gravel; Pc—Pennsylvanian (Canton) shale.

bayment and by the occurrence of Tertiary wood in the gravels near Grover, St. Louis County, Missouri (Rubey, 1931). Because the Eocene formations were beveled by the Ozark peneplain before deposition of the gravels, a late Tertiary age is indicated. A similar age for the gravels in western Illinois is evidenced by their occurrence on a buried bedrock surface which appears to be the northward continuation of the Ozark peneplain (Horberg, 1946, pp. 186-188).

Interpretation

The gravels in Henry County probably were derived largely from residual accumulations on Silurian formations, which occur less than 20 miles to the north, and were deposited, along with pre-Cambrian materials from farther north, by a south-flowing stream. This is evidenced by the composition of the gravels and their angularity and poor sorting. The absence of locally-derived Pennsylvanian rocks in the gravels further suggests that they represent a widespread aggradational deposit rather than a channel fill and also that they are primary rather than locally re-worked from older gravels.

The physiographic position and character of the gravel in Henry County are in full accord with other occurrences in the Mississippi Valley region and suggest that the following major geomorphic events were contemporaneous over a wide area:

1. Development of the Lancaster-Calhoun-Ozark peneplain in middle to late Tertiary time. Weathering of the Canton shale in Henry County.

2. Uplift of gravel-source areas to the north and initiation of a new cycle marked by gravel deposition. Removal of the upper part of the weathered zone on the Canton shale and deposition of gravel in the local area by a south-flowing stream.

3. Development of the Central Illinois peneplain and Havana strath in central Illinois (Horberg, 1946). Weathering of gravels and

probably some subsequent erosion and redeposition in western Illinois.

4. Erosion of deep bedrock valleys and removal of gravels except for patches on remnants of the Lancaster surface.

5. Pleistocene glaciation resulting in further stripping of gravels and their final burial. Henry County probably was glaciated during the Nebraskan and Kansan stages, as well as the Illinoian, although the record at the gravel locality is incomplete.

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THE NEDA FORMATION IN NORTHEASTERN ILLINOIS[1]

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In the vicinity of Mayville, Wisconsin, an "oolitic hematite" called "seed ore," "flaxseed ore," or "shot ore," was originally designated by Chamberlin[3] as the "Clinton iron ore deposit." He described the grains of iron ore as "little lens-shaped concretions" composed of hydrated hematite averaging 1/25 inch (1 mm.) in diameter, but varying from 1/10 inch (2.5 mm.) to those that are very minute. Cross sections indicated that the ore occurs between the Cincinnati shale and the "Niagara limestone." He stated that, although a few fossils of Cincinnatian age were reported to have been found in ore enclosed in a mass of glacial drift, an obvious unconformity at its base in outcrop and a less apparent break at the top indicate the deposit to be Silurian. He suggested that it was made in detached shallow basins over which the succeeding Silurian sea spread more widely. Figure 1 is a photograph of ore recently obtained at Mayville.

Thwaites[4] further described the deposits of "Clinton" ore as occurring in eastern Wisconsin in broad lenses varying in thickness up to a known maximum of 55 feet. He pointed out that at many places where the iron ore is not present there are nevertheless beds of red rock at the same horizon, and presented a map (fig. 2) showing the known occurrences of iron ore and red rock. He reported also that in the Green Bay region the ore is interbedded with shale, and in an area

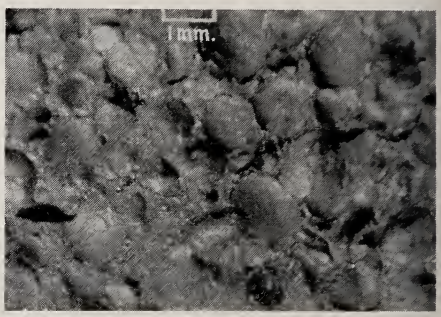

FIG. 1.—Neda Iron Ore from Mayville, Wisconsin (X6).

about 15 miles southeast of Mayville it appears from well cuttings to be broken up and mixed, or perhaps interstratified, with limestone.

Savage and Ross[5] pointed out that the relations of the iron ore to formations both above and below are unconformable, but that fossils collected from the ore in place indicate it to be of Maquoketa (Cincinnatian) age. They described the deposit as containing pebbles of shale, iron ore, and iron-oxide-replaced fossil fragments and suggested that the deposit is a formation laid down in local basins that, because of the presence of marine fossils, probably were connected and remained after the main portion of the normal marine Maquoketa sea had withdrawn from the greater part of the region

[1] Published by permission of the Chief, Illinois State Geological Survey. (Presented at the 1949 meeting of the Academy.)

[2] Geologist and Head, Subsurface Geology Division.

[3] Chamberlin, T. C., Geology of Wisconsin, Wisconsin Geol. Sur., vol. 2, 1878, pp. 327-335.

[4] Thwaites, F. T., Recent discoveries of "Clinton" iron ore in eastern Wisconsin, U.S.G.S. Bull. 540, 1914, pp. 338-342.

[5] Savage, T. E., and Ross, C. S., The age of the iron ore in eastern Wisconsin, Am. Jour. Sci., Fourth Series, vol. 41, 1916, pp. 187-193.

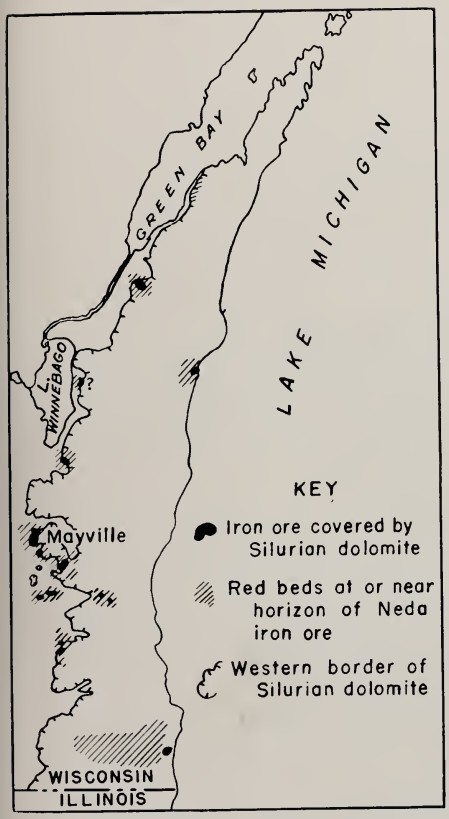

FIG. 2.—Locations of Neda Iron Ore in Wisconsin (after Thwaites).

farther south in the Mississippi valley. They named it the "Neda Iron Ore" formation.

Hawley and Beavan[6] made a detailed analysis of the minerals of the Neda Iron Ore formation. They determined that nuclei observed in the oolites consist of: (a) fragments of reworked ore, (b) fossil fragments, (c) mineral or rock fragments, and (d) cross-shaped objects. They emphasized, however, that most of the oolites show no central nuclei. They showed that the spheroids are composed of at least 26 varieties of minerals, chief of which are goethite (Fe_2O_3,H_2O), calcite, and halloysite ($Al_2O_3.2SiO_2.nH_2O$). Halloysite is a clay that was found to compose most of the insoluble residue after treatment with acid and that looked under the binocular microscope like finely granular unglazed porcelain, making up the fragile spheroidal shells of the spheroids. There are ten varieties of phosphates, and 50% of all phosphorus is contained in the outer shells of the spheroids. The non-oolitic portion of the ore is largely pore space. Crystalline hematite has grown from the spheroids into part of the space, and there are a number of sedimentary minerals such as quartz and materials from the weathering of igneous rock. The most abundant transported material consists of angular grains of scoriaceous lava largely altered to iron oxide. There are rounded fragments of reworked ore and nodules of calcite and dolomite. The authors state that the source of the predominant ore minerals is a baffling problem.

The Neda iron-bearing formation is reported in the same stratigraphic position in eastern Iowa[7], eastern Kansas[8], and northwestern Missouri[9].

Athy[10] very fully described the Neda deposit in Illinois but called it the Noix Oolite of basal Alexandrian (Silurian) age. The outcrops which he described, situated in sections 26, 27, and 35, T.32 N., R.10 E., Kankakee County, are the only ones known in Illinois. He reports the iron ore spheroids as occurring in a

[6] Hawley, J. E., and Beavan, A. P., Mineralogy and genesis of the Mayville iron ore of Wisconsin, Amer. Mineralogist, vol. 19, 1934, pp. 493-514.

[7] Howell, J. V., An outlier of the so-called Clinton formation in Dubuque County, Iowa, Proc. Iowa Acad. Sci., Vol. XXIII, 1916, pp. 121-124.

[8] Lee, Wallace, The stratigraphy and structural development of the Forest City Basin in Kansas, Geol. Sur. Kan., Bull. 51, 1943, p. 42.

[9] Crane, G. W., The iron ores of Missouri, Missouri Bur. Geol. and Mines, 2nd Series, Vol. X, 1912, pp. 148-149.

[10] Athy, L. F., Geology and mineral resources of the Hersher quadrangle, Ill. Geol. Sur. Bull. 55, 1928, pp. 33-38.

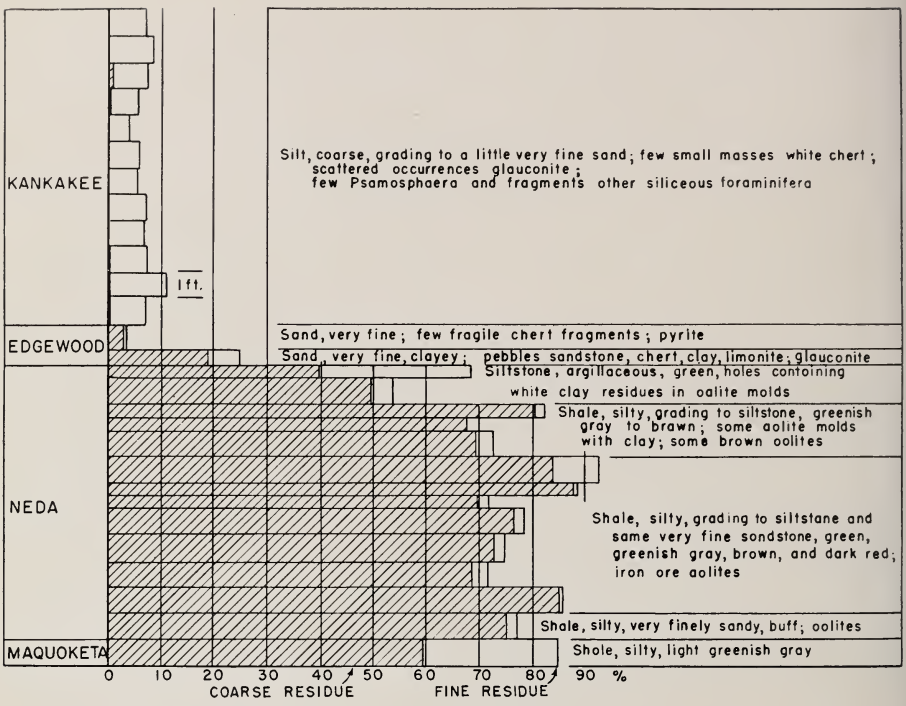

FIG. 3.—Graph of insoluble residues from Neda formation and associated strata in outcrop above spring in NW. ¼ SE. ¼ NE. ¼ sec. 27, T. 32 N., R. 10 E., Kankakee County, Illinois.

matrix of reddish brown, purplish, and green ferruginous shales and shaly dolomite reaching a thickness of 8 feet, 2 inches, and resting unconformably on olive-green Richmond (Maquoketa) shale. The spheroids are generally the size of fine to coarse sand averaging .5 mm. across. The shale was reported to contain much silt and fine quartz sand (up to .25 mm. diam.) and some medium sand (.25 to .50 mm.).

The writer obtained insoluble residues from samples, taken at one-foot intervals or less from several of the outcrops along Kankakee River, by treating the rock samples with weak hydrochloric acid. The graph of the most complete section (fig. 3), taken at the locality figured by Athy on page 32 and described on page 33 (see footnote 10), shows 10½ feet of Neda ore-bearing material on top of the Maquoketa shale and under the Edgewood formation. The insoluble material of the Neda deposit consists of: (a) silty shales to siltstones variously colored brown, yellow, greenish, and purplish by iron oxide cement; (b) some very fine sand that grades in the middle of the deposit to very fine sandstone; (c) iron-ore spheroids scattered in variable proportions but nowhere composing most of the deposit as in Wisconsin. The total residue varies from 54 to 93 percent. These proportions are not essentially different from the proportions in the Maquoketa shale below, which in the single sample taken amounted to 85 percent. Neither is the silty shale to siltstone matrix greatly different, except for some sand content, from the

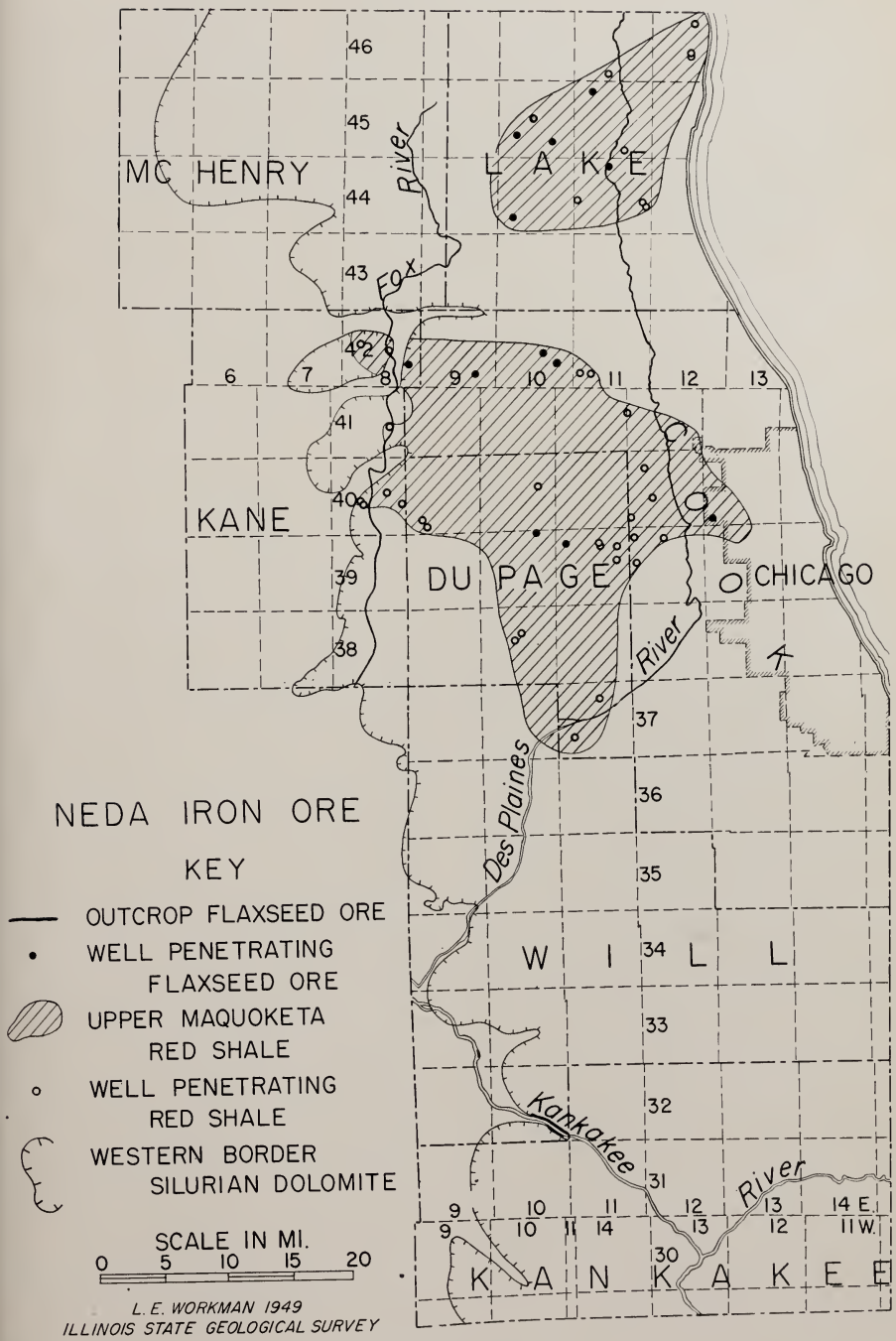
MC HENRY
LAKE
KANE
DU PAGE
COOK
CHICAGO
WILL
KANKAKEE
Fox River
Des Plaines River
Kankakee River
NEDA IRON ORE
KEY
OUTCROP FLAXSEED ORE
WELL PENETRATING FLAXSEED ORE
UPPER MAQUOKETA RED SHALE
WELL PENETRATING RED SHALE
WESTERN BORDER SILURIAN DOLOMITE
SCALE IN MI.
0 5 10 15 20
L. E. WORKMAN 1949
ILLINOIS STATE GEOLOGICAL SURVEY

FIG. 4.

Maquoketa silty shale. On the other hand, the residue proportions are quite different from the 25 percent residue of the overlying Edgewood and there is an abrupt change from the silty sandy shale below to a sandy conglomeratic dolomite above. The pebbles of the conglomerate consist of grains of underlying shale and a few weathered iron ore spheroids. Were it not for the pebbles the proportion of insoluble residue of the lowest sample of Edgewood would be similar to that of the next sample above, that is, less than 10 percent.

In the subsurface of the Chicago region (fig. 4) the spheroids of iron ore are found in a variety of sediments. Like those along Kankakee River, they occur in silty shales having various iron-oxide colors. As in the Wisconsin outcrops, they occur as spheroids loosely cemented with crystalline hematite, though the beds are so thin that only a relatively small part of a 5-foot well sample consists of such material. They are commonly associated with red to green weak silty clay that contains small pebbles and grains of weathered Maquoketa dolomite. In some samples they appear to occur in a yellowish brown silty clay which has a starch-like fracture and contains brown flakes, suggesting a soil zone. In one sample the spheroids occur in a very fine sandstone containing grains of dolomite, hematite, and a hematite-replaced spicule. All occurrences are in the midst of more extensive areas where the top of the Maquoketa is represented by red clay shale containing weathered dolomite fragments. Such red shale areas are present only where the Maquoketa reaches its maximum thickness of 190 to 250 feet, as may be noted by comparison with DuBois'[11] isopach map of the Maquoketa (fig. 5).

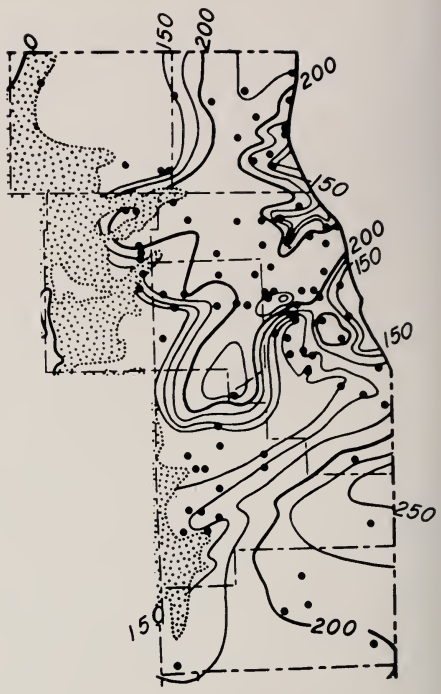

Fig. 5.—Thickness of Maquoketa formation in the Chicago region; isopach interval 25 feet (after DuBois).

Elsewhere in Illinois Neda spheroids have been noted in two wells in eastern Whiteside County and in another in eastern Peoria County where the Maquoketa thickness is near a maximum for the region of a little more than 200 feet. All these conditions are interpreted as indicating that the Neda was deposited on a relatively flat surface of the Maquoketa and was eroded widely along with the Maquoketa formation in an interval previous to Edgewood deposition.

The iron-oxide spheroids in the matrix of silty shale of the Neda de-

[11] DuBois, E. P., Subsurface relations of the Maquoketa and "Trenton" formations in Illinois, Illinois Geol. Survey Rept. Inv. 105, fig. 1, p. 8., 1945.

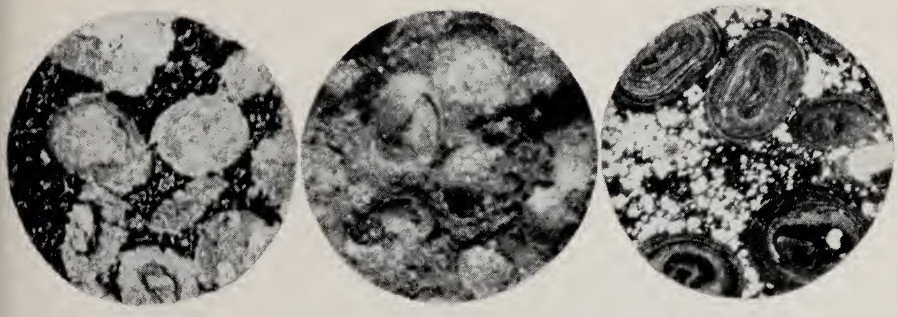

FIG. 6.—(Left) Thin section of Neda iron oxide spheroids in matrix of silty shale from Illinois (X18).

FIG. 7.—(Middle) Broken surface of Neda silty shale showing spheroids altered to clay (X18).

FIG. 8.—(Right) Thin section of Neda deposit showing spheroids replaced by calcite (X18).

posit in Illinois are generally smaller than those in Wisconsin, ranging up to 1 mm. in larger diameters, only a few reaching 1.25 mm. diameter, and averaging .75 mm. or less. They are similar in appearance to those in Wisconsin, being generally spheroidal and having smooth surfaces not only on the outsides of grains but on secondary surfaces made by breaking off the oolitic shells. Many of the spheroids in thin section show no nuclei, but the most common nuclei observed are fragments of other spheroids, especially fragments of the outer shells (fig. 6). A few were observed that were fragments of the matrix of silty shale, and a very few contained single silt grains or other material at the center. Most of them show a slightly darker brown outer hull.

Some observations of interest in considering the composition and geologic history of the oolites are as follows:

1. In the upper portions of outcropping Neda beds, varying in observed thickness from a few inches to as much as eight feet, the former oolites which were subjected to weathering previous to Edgewood deposition lost their iron-oxide content, leaving a residuum of clay (fig. 7). This clay has been identified by Grim[12] as illite. Usually its texture is dense and porcelaneous, showing only faintly or not at all the former concentric rings of the oolites. The dull olive-green color disappears on treatment of the sample with acid, leaving the clay almost white. These clay masses appear slightly smaller than the average iron-ore spheroid, and the shapes of the cavities in which they occur, though roughly spheroidal, are somewhat distorted, indicating that the sediments have been somewhat compacted to fill partly or entirely the former oolite spaces. However, it becomes evident that, because of the large amount of residual clay, some original spheroids were not highly iron-bearing. Some clay masses are soft and porous, and occupy proportionately less space than the dense variety in the cavity left by solution of the iron oxide. Some consist only of flat round blebs of green clay in sizes typical of the oolites. Evidently these last formerly contained high

[12] Grim, Ralph E., personal communication.

proportions of iron oxide before the iron was dissolved and the sediments collapsed.

2. Some of the former oolites contain partial replacements of gray crystalline calcite (fig. 8). The cleavage faces of the calcite are so oriented as to indicate that each oolite replacement developed as a single crystal. Surrounding the crystal mass is the residual clay. Some of the calcite masses occupy practically all the former oolites except the outer hulls, whereas others are smaller and the residual clay masses seem to be larger accordingly. It is suggested that calcite formation took place only after the cavities had been left by iron-oxide solution and that the sizes of the crystals were governed by the available space. Thus it would appear that the calcite deposited after the beginning of Edgewood time, possibly long after that time.

3. Some of the residual material enclosing the calcite grains has the appearance of perfect fragments of outer hulls of iron-ore spheroids except that they are dark brown to black, suggesting the presence of organic material. Kosanke[13] examined some of these and reported that they show no cellular structure but appear rather to be composed of amorphous material. Upon being heated in a test tube the black color disappears, leaving light-brown amorphous clay suggestive of that described by Hawley and Beavan as halloysite in the hulls of oolites in Wisconsin and of a somewhat different chemical character than the materials making up the remainder of the oolite.

The considerable variety of sedimentary materials in which the iron-ore spheroids are found, the occurrence of the spheroids in northeastern Illinois and elsewhere only where the Maquoketa is thickest, and recognition of the same type of iron-ore spheroids at about the same geologic horizon in widely separated areas from Kansas to Wisconsin and Illinois, suggest that the Neda formation was a widespread deposit of variable character lying upon known Maquoketa (Cincinnatian) shale, and was to a great extent eroded away during pre-Edgewood (pre-Lower Alexandrian) uplift. It appears significant for considerations of correlation that the Neda type of oolite occurs elsewhere in the eastern half of the United States in Silurian strata only, that is, the Red Mountain formation of Upper Alexandrian and Lower Niagaran ages in the Birmingham District, and the Clinton group of Lower Niagaran age in New York.

There is no difficulty in assuming that conditions of deposition favorable to the formation of Neda oolite recurred at intervals from late Cincinnatian to early Niagaran times, but in order to be sure that these conditions prevailed across the Ordovician-Silurian boundary the possibility should be examined that the Maquoketa fossils found in the Neda in both Wisconsin and Iowa may have attained their position by being reworked by an early Silurian sea.

[13] Kosanke, R. M., personal communication.

PHYSICS

SURVEY OF CITY NOISE

G. L. BONVALLET

Armour Research Foundation of Illinois Institute of Technology, Chicago

A survey of city noise has been in progress in Chicago for over two years. The program covers noise of transportation vehicles, and noise in traffic lanes, industrial, and residential areas. The study is sponsored by Armour Research Foundation of Illinois Institute of Technology and the Greater Chicago Noise Reduction Council, and has the cooperation of the City of Chicago and the National Noise Abatement Council.

The work was undertaken as a public service and to stimulate further interest in the subject. Not only has the noise problem become more acute with the passing of time, but the public has become reconciled to noise as a necessary condition of present-day living. Furthermore, good methods of simply, rapidly, and reliably measuring industrial noise have not been available to the engineer. Equipment is available for measuring sound intensity, but acousticians agree that there is little correlation between sound levels, which are a measure of the physical condition in the medium, and loudness as adjudged by the human ear. It is hoped, therefore, that the results of the survey will create interest in further work, and will, in addition, establish a preliminary basis for tolerable noise levels which will be useful in writing or revising anti-noise legislation.

A study of city noise was made in New York City in 1930.* The results of this work were far-reaching and beneficial. Other surveys on a smaller scale have been made by a number of workers.

An important part of the present study has been that of taking octave band levels in addition to over-all levels. The over-all level is that indicated by a standard sound meter which responds to the entire audible spectrum within the limitations of the meter. The octave band levels are those read on the sound meter which has been modified by switching in various band pass filters. The meter then indicates the level within the particular band. The bands referred to in this paper are one octave wide.

Many acoustical measurements of mechanical noises have indicated the unreliability of the single over-all measurement to represent the objectionable degree of the noise. It is well known that levels in the various octave bands are more valuable in describing the noise than the single over-all level. As a result of numerous listening judgments on noises similar to these, it has been found that the loudness and objectionable nature of such noises could be correlated better with one of the octave measurements, such as the 400-800 cps band,

* *City Noise*, published by the Noise Abatement Commission of the City of New York, The Academy Press, New York, 1930.

than with the single over-all level. This particular band represents a good compromise between lower frequency octave levels with high energy content and higher octave band levels with reduced energy, because of the absorption by intervening structures and air.

Noise of Vehicles

The phase of the survey concerned with noise of common transportation vehicles was started first because vehicle and traffic noise was believed to be more objectionable and more prevalent than industrial noise. The work has been completed, and with curves and tables is rather comprehensively reported in the *Journal of the Acoustical Society of America,* Vol. 22, Number 2, March 1950.

Inside vehicles, the highest average levels were measured in subway cars. These were 95 db over-all and 91 db in the 400-800 cps band. All measurements are on the flat network. The lowest average levels were 85 db over-all in a new "L" car and 68 db in the 400-800 cps band measured in a relatively new seven-passenger sedan. Levels for such vehicles as old "L" cars, old street cars, trolley buses, PCC cars, motor buses, and suburban steam and electric railroad cars were between these maximum and minimum values.

Outside vehicles, the noise was measured at 20 feet in all cases except for railroad trains, in which case a distance of 100 feet was believed to be more practical for the purpose. The highest average levels were for subway trains and the levels were 94 db over-all and 87 db in the 400-800 cps band. The lowest average over-all level was 79 db for trolley buses. The lowest average level in the 400-800 cps band was 66 db for automobiles.

Traffic Noise

Although traffic noise generally is more intense than industrial noise, in many cases it may be adjudged less objectionable. This follows because: (a) the public may tolerate public transportation noise on the incorrect basis that it cannot be reduced, and (b) vehicle noise, aside from automobile horns, squealing brakes, and clanging street car gongs, when close to a listener, increases slowly as the vehicle approaches and then decreases. Industrial noise, on the other hand, often changes abruptly. Generally it stops and starts suddenly and may be objectionable because of its characteristic quality which identifies it as a forging hammer, steam exhaust blast, a traveling crane, a whistle, metal handling, or the like.

Measurements have been made at intersections and in thoroughfares to ascertain levels due to traffic. Insufficient data have been taken for a complete picture of the range of over-all and octave band levels. Based on the meager data, the over-all levels ranged from about 65 to 85 db, and the levels in the 400-800 cps band from 45 to 70 db. These figures are for places where a reasonable amount of city traffic, such as automobiles, trucks, and mass transportation vehicles, passes.

Industrial Noise

Another phase of the survey concerns noise in industrial areas. Over a hundred different places in the many Chicago industrial zones were visited and data taken during the usual business hours. Measurements were taken from the sidewalk, street,

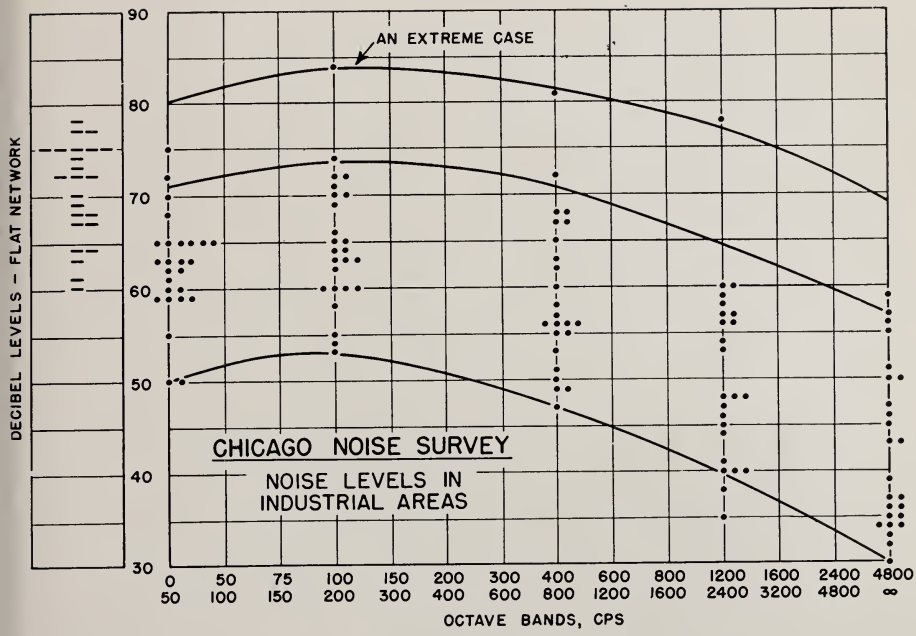

FIG. 1.—Data and curves of noise in industrial areas. Measurements (flat network) are on the sidewalk or street about 25 to 30 feet from buildings or plant boundaries and during usual daytime business hours.

or other public thoroughfare on the outside of each plant or industrial area. Distances generally were about 25 to 30 feet from a building or boundary. In many cases it was difficult to establish a meaningful sound level because of the intermittent nature of the noise. Information on whether the noise was above or below the general background noise also was noted.

Preliminary study of the data indicates a range in over-all levels of about 60 to 90 db. Measurements in the 400-800 cps octave band ranged from 45 to 80 db. Typical levels are shown in figure 1. This figure also shows the value of octave band data in describing the noise as compared to the single over-all level. Despite the incompleteness of these data, they have been used to make preliminary curves and draw preliminary conclusions. Figure 2 shows the distribution of noise levels measured in the 400-800 cps band. The curve shows that about 95 percent of the levels fall below 70 db. Assuming that these data are confirmed after complete analysis of the measurements, a preliminary conclusion might be drawn that 5 percent of the cases should be considered objectionably loud.

Figure 3 might be termed a preliminary limiting curve for industrial noise. It has the same general shape as industrial noise curves and passes through the previously mentioned 70 db level in the 400-800 cps band. It would define a noise spectrum such that industrial noise with higher components than those shown might be considered legally objectionable. Such measurements and curves require complete and careful analysis before conclusions can be made.

The study indicates one important observation even at the present stage. Industrial noise outside plants and factories is not so loud as it is reputed to be. The few factories that make intense noise probably have given a bad reputation to industry in general. Many cases were found where the plant noise could not be measured in the background of unidentifiable sounds or of transportation vehicle or traffic noise.

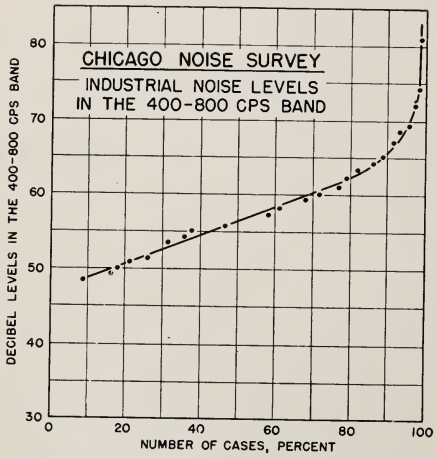

Fig. 2.—Curve showing the percentage distribution of industrial noise levels measured in the 400-800 cps band. From these data it can be seen that about 95% of the cases are below 70 db in the specified octave band.

Residential Area Noise

The data on residential noise are rather meager at the present time. The background levels are caused by industrial or traffic noise at different distances. Nearby vehicles, children at play, vendors, and other local sources generally do not contribute much to the ambient background, although they often are objectionable. Again, with incomplete analysis, the data indicate a range of from 50 to 80 db over-all and 35 to 70 db in the 400-800 cps band. As before, compromises are required in associating a single level with complicated noise conditions such as these.

Automobile Horns

An investigation of automobile horns is being conducted as a part of the survey. It was felt that such a study was of value because of the necessity for horns on vehicles and the objectionable nature of some of them. It is necessary that a horn be louder than the ambient background noise and even loud enough to warn nearby motorists in totally enclosed automobiles operating at noisy high speeds. Such warning signals, therefore, are required to be comparatively intense sound sources. On the other hand, many such horns are unduly loud. It is believed that horns can be effective without being raucous despite their relatively high levels. The work in progress consists in part in measuring the levels and in investigating the overtone structures to determine the characteristics of pleasant and effective signals on the one hand and characteristics which are objectionable and which possibly identify the horns as dangerous because of their frightening effect.

Again it must be reported that the work is not yet completed and only a report of progress can be made here. The modern automobile for the last five years has employed horns in pairs. The present work is simplified because most of the automobiles now on the streets employ only about half a dozen types of horns. The fundamental tones of the two horns in the pair are usually a musical major third apart. The more

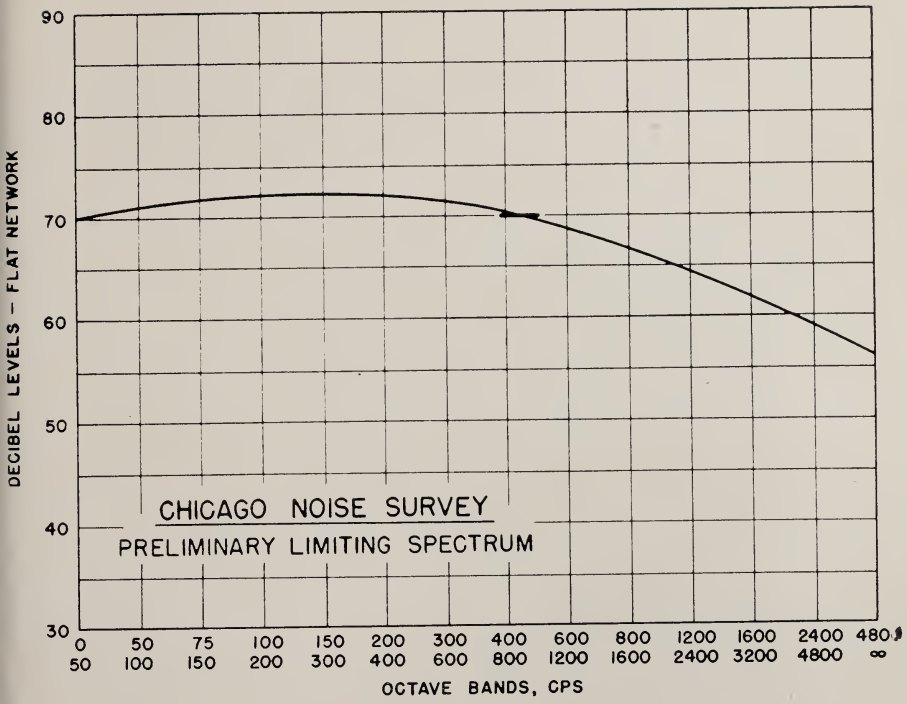

FIG. 3.—Curve showing a preliminary limiting spectrum. The curve is similar to others for industrial noise and passes through 70 db in the 400-800 cps band. Industrial noise data which are higher than this curve might characterize the source as legally objectionable.

pleasant sounding devices have harmonic overtones, whereas the objectionable sounding horns have inharmonic overtone structures.

Measured at three feet in front of the units, these horns have levels of from 105 to 125 db, so far as they have been measured. The fundamental tones for the different horns are in the range of about 150 to 400 cps.

An important feature of the work is that, in addition to the levels in decibels, the information in phons and sones also is being determined. There has been too little work done in the industrial field in the way of obtaining loudness and loudness levels. This has been due, at least in part, to the difficulty and the labor involved in determining these from decibel levels. As an example, the range of 105 to 125 decibels is a range in loudness level of approximately 125 to 140 phons and range in loudness of about 600 to 2000 sones.

It is desirable to define these units here. The loudness of a sound is the magnitude of sensation in the ear. It depends on sound pressure and on the frequency spectrum. The unit is the loudness unit or the sone. A 1000-cycle tone 40 db above the normal threshold has a loudness of one sone or 1000 millisones or loudness units. The loudness level of a sound is numerically equal to the sound pressure level in decibels of the simple 1000-cycle reference tone which

is judged to be equally loud. The unit of loudness level is the phon.

The program includes the processing of these horn noises in several ways, such as filtering the output to cut off at around 1000 cps. Again in a preliminary way, it has been found that such filtering removes a reasonable amount of the sound which is objectionable, and apparently does so without sacrificing the necessary warning characteristics.

Conclusion

The survey is proceeding at the present time with analysis of available data and with plans for the incomplete phases referred to above. Of more importance, further thought is being given to the problem of using these results beneficially. As the work becomes completed the results will be made available in the most useful way.

SPECTRAL CHARACTERISTICS OF FLASH DISCHARGES

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A "flash" discharge may be defined as an electrical breakdown produced by the discharge of a condenser through a gas at pressures of the order of 100 mm of mercury. It is characterized by a high current pulse of short duration accompanied by a brilliant white flash of light. The duration of the current pulse is of the order of 10 microseconds while the period of the light flash may be considerably longer, persisting for 100 microseconds or more in heavy discharges.

Many practical uses have been found for such lamps. Originally developed for high-speed photography and stroboscopic uses, they have more recently been employed in aerial photography, as a source of artificial sunlight in making moving pictures, and for emergency lighting of landing fields. Figure 1 shows several types of flash lamps. A, B, C, and G are forms of commercial photo-flash lamps; D, E, and F are examples of experimental models of flash tubes.

The maximum brightness of these lamps when used to produce single heavy discharges may exceed the brightness of the sun by a factor of ten with a peak flux output of a hundred million lumens. Currents of several thousand amperes are produced with instantaneous rates of energy input of several megawatts.

The physical characteristics of the emitted radiation are of considerable scientific interest. In the first place, the main component of the radiation is an intense continuum in the case of discharges where the current density is 20,000 amp/cm^2 or higher. This in itself is unusual, since normally a gas is expected to radiate chiefly bright lines characteristic of the excited atoms and molecules present in the discharge.

In the second place, the line spectra which appear superimposed on the continuous background exhibit many anomalies when compared to the lines emitted by low intensity arc discharges in the same gas. A study has been made of these anomalies, both with reference to the energy input per flash, and also as a function of time during the various phases of the flash. This paper attempts only a very brief summary of the results of this study.

The Continuum

When measurements are made of the energy distribution of the continuum in the "integrated" flash, a broad distribution is found as a function of wave length. In the case of intense discharge a maximum occurs at about 4500 AU, corresponding to a black body temperature of roughly 10,000°K. The radiation density values, however, indicate much higher temperatures.

Most theories agree in ascribing the origin of these continuous wave lengths to "free-free" electron transitions with ions in the high density plasma existing in these discharges, and also to electron-ion recombination, or "free-bound" tran-

COMPARISON OF XENON ARC AND FLASH SPECTRA
(3,500 to 6,200 A.U.)

λ(A.U.)	Spectrum I	Spectrum II	Transition	D.C. Arc	45 Watt Flash	720 Watt Flash	Xe^+	Xe
6098		x	$(^3P)\ 5d\ {}^4D_{5/2} - (^3P)\ 6p\ {}^4P_{3/2}$			x	II	
6036		x	$(^3P)\ 5d\ {}^4D_{5/2} - (^3P)\ 6p\ {}^4P_{5/2}$			x	II	
5976		x	$(^3P)\ 6s\ {}^4P_{3/2} - (^3P)\ 6p\ {}^4P_{5/2}$			x	II	
5824	x		$1s_3 - 5X$	x				
5668		x	$(^3P)\ 5d\ {}^4D_{3/2} - (^3P)\ 6p\ {}^4P_{1/2}$			x	II	
5473		x	$(^3P)\ 5d\ {}^4D_{7/2} - (^3P)\ 6p\ {}^4D_{7/2}$			x	II	
5419		x	$(^3P)\ 6s\ {}^4P_{3/2} - (^3P)\ 6p\ {}^4D_{5/2}$		x	x	II	
5372		x	$(^3P)\ 6s\ {}^4P_{3/2} - (^3P)\ 6p\ P^\circ_{1/2}$			x	II	
5339		x	$(^3P)\ 6p\ {}^4D_{3/2} - (^3P)\ 6d\ {}^4D_{7/2}$		x	x	II	
5292		x	$(^3P)\ 6s\ {}^4P_{5/2} - (^3P)\ 6p\ {}^4P_{5/2}$		x	x	II	
5191		x	$(^3P)\ 6s\ {}^4P_{1/2} - (^3P)\ 6p\ {}^4D_{1/2}$			x	II	
5122		x	$(^3P)\ 6p\ {}^4P_{1/2} - (^3P)\ 7s\ {}^4P_{3/2}$			x	II	
5081		x	$(^3P)\ 6p\ {}^4D_{5/2} - (^3P)\ 7s\ {}^4P_{3/2}$			x	II	
5028	x		$1s_4 - 3p_{10}$	x				
4923	x		$1s_4 - 3p_9$	x	x	x		I
4917	x		$1s_4 - 2p_4$	x	x			
4884		x	$(^3P)\ 6s\ {}^4P_{1/2} - (^3P)\ 6p\ {}^4S_{3/2}$			x	II	
4844		x	$(^3P)\ 6s\ {}^4P_{5/2} - (^3P)\ 6p\ {}^4D_{1/2}$		x	x	II	
4843	x		$1s_4 - 3p_6$	x	x			
4830	x		$1s_4 - 3p_7$	x	x			
4807	x		$1s_4 - 3p_5$	x	x			
4734	x		$1s_4 - 2p_3$	x	x	x		I
4671	x		$1s_5 - 3p_8$	x	x	x		I
4624	x		$1s_5 - 3p_6$	x	x			
4603		x	$(^3P)\ 6s\ {}^4P_{3/2} - (^3P)\ 6p\ {}^4D_{3/2}$			x	II	
4545		x	$(^3P)\ 6p\ {}^4D_{5/2} - (^3P)\ 6d\ {}^4D_{7/2}$			x	II	
4525	x		$1s_5 - 2p_3$	x				
4501			$1s_5 - 2p_2$	x				
4481		x	$(^3P)\ 6p\ {}^4D_{3/2} - (^3P)\ 6d\ {}^4F_{5/2}$			x	II	
4415		x	$(^1D)\ 6s\ {}^2D_{5/2} - (^1D)\ 6p\ {}^2D_{3/2}$			x	II	
4393			$(^3P)\ 6p\ {}^4S_{3/2} - (^3P)\ 6d\ {}^2D_{5/2}$			x	II	
4386 or 4384	x		$1s_4 - 4X$ or $1s_4 - 4Y$	x				
4331		x	$(^3P)\ 6p\ {}^4D_{5/2} - (^3P)\ 6d\ {}^4F_{7/2}$			x	II	
4194	x		$1s_5 - 4U$	x				
3968	x		$1s_5 - 4p_8$	x				

TABLE 1.

sitions. The latter mechanism would be expected to be the predominant cause of continuous radiation in the "afterglow," or decaying portion of the light flash which persists after current ceases to flow in the arc.

To obtain a complete analysis of the electrical and radiation properties of these discharges it is necessary to make measurements as a function of time during the very short period of the flash. This is difficult in the case of the ordinary spark discharge across a gap at atmospheric pressure because of the extremely erratic behavior of the spark. However, by employing rare gases to avoid chemical reactions, and pressures of from 25 mm to 100 mm Hg, it is possible to obtain highly reproducible flash discharges in repetitive operation. The flash can be initiated with great precision, and accurate reproduction of current, potential, and photo-current showing the change of radiation intensity with time can be obtained on the oscilloscope screen.

Fig. 1.—Types of commercial and experimental flash tubes.

Figure 2 illustrates how the current and the continuous radiation change with time for flash discharges in argon and neon tubes. These discharges are "triggered" by means of a sharp voltage pulse applied to an auxiliary electrode which causes enough ionization for a heavy arc current to form and discharge a condenser attached to the electrodes. These traces are taken from the oscilloscope screen.

Three types of phototube multipliers were used to register the intensity of radiation in three spectral regions: the ultraviolet (2400 to 4200 AU), visible (4600 to 7000 AU) and the near infrared (7000 to 12,000 AU). In obtaining these results the amplitude of each photocurrent plot was arbitrarily adjusted, so they cannot be intercompared. The total radiation in the visible and ultraviolet regions is much greater than in the infrared. It is noted that in all cases the peak light occurs much later than peak input current (or power), this lag being greatest for the longer wave lengths.

Variation of Characteristic Line Spectra

A study of the line spectra is of particular interest to the physicist who desires information concerning fundamental processes occurring in this type of discharge. He wishes to determine the processes leading to breakdown of the gas, the current conduction mechanism, temperatures and ion densities in the column, the cause of the lag of radiation behind current, and the nature of the processes occurring in the gas plasma during the afterglow period. In general, our knowledge of the detailed processes occurring in the flash and spark discharges is quite incomplete compared to our

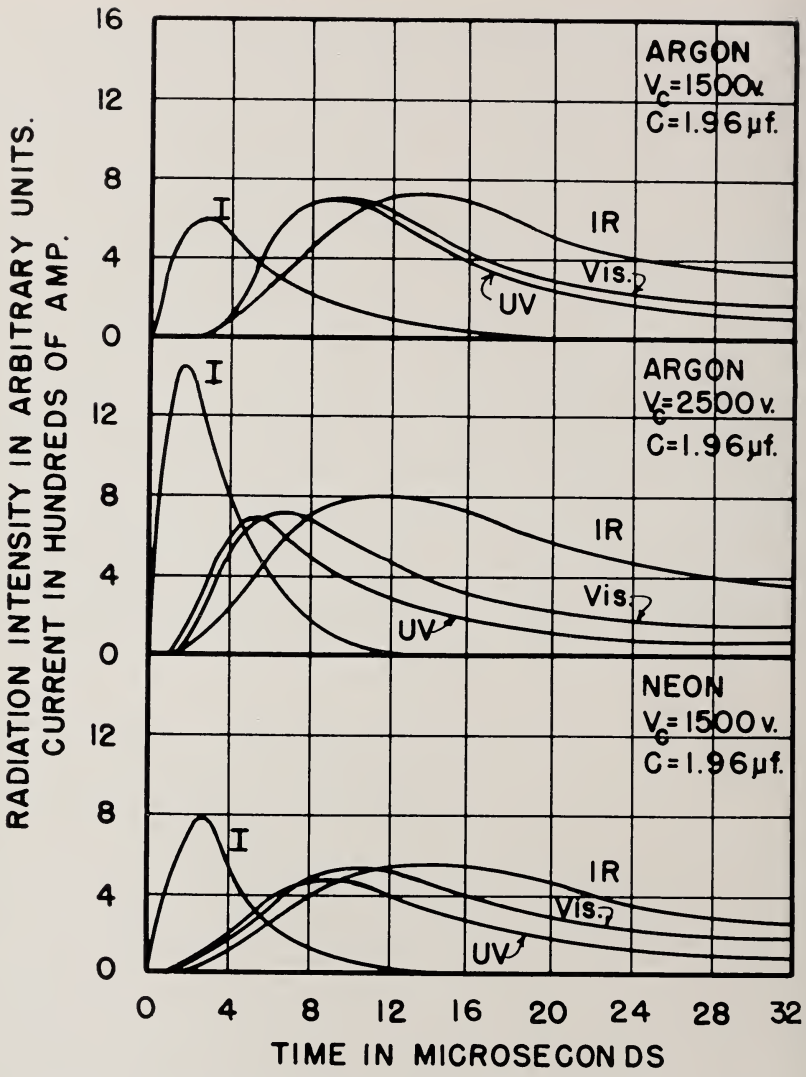

FIG. 2.—Oscillographic traces of current and radiation in argon and neon quartz flash lamps.

understanding of other types of steady discharges.

Spectrograms were made of discharges in xenon for the total flash period, and compared with the lines appearing in a low current steady arc discharge in the same gas. Table 1 gives a summary of results for the strong lines observed in the visible region. In the d-c low current arc only arc lines (Xe I) are observed. For low energy flashes a number of these same arc lines are observed, and in addition several spark lines (Xe II) appear, lines which are due to excitation of xenon ions. Lines appearing superimposed on the strong continuum in the high energy flash discharge are shown in the column on the right. Here only

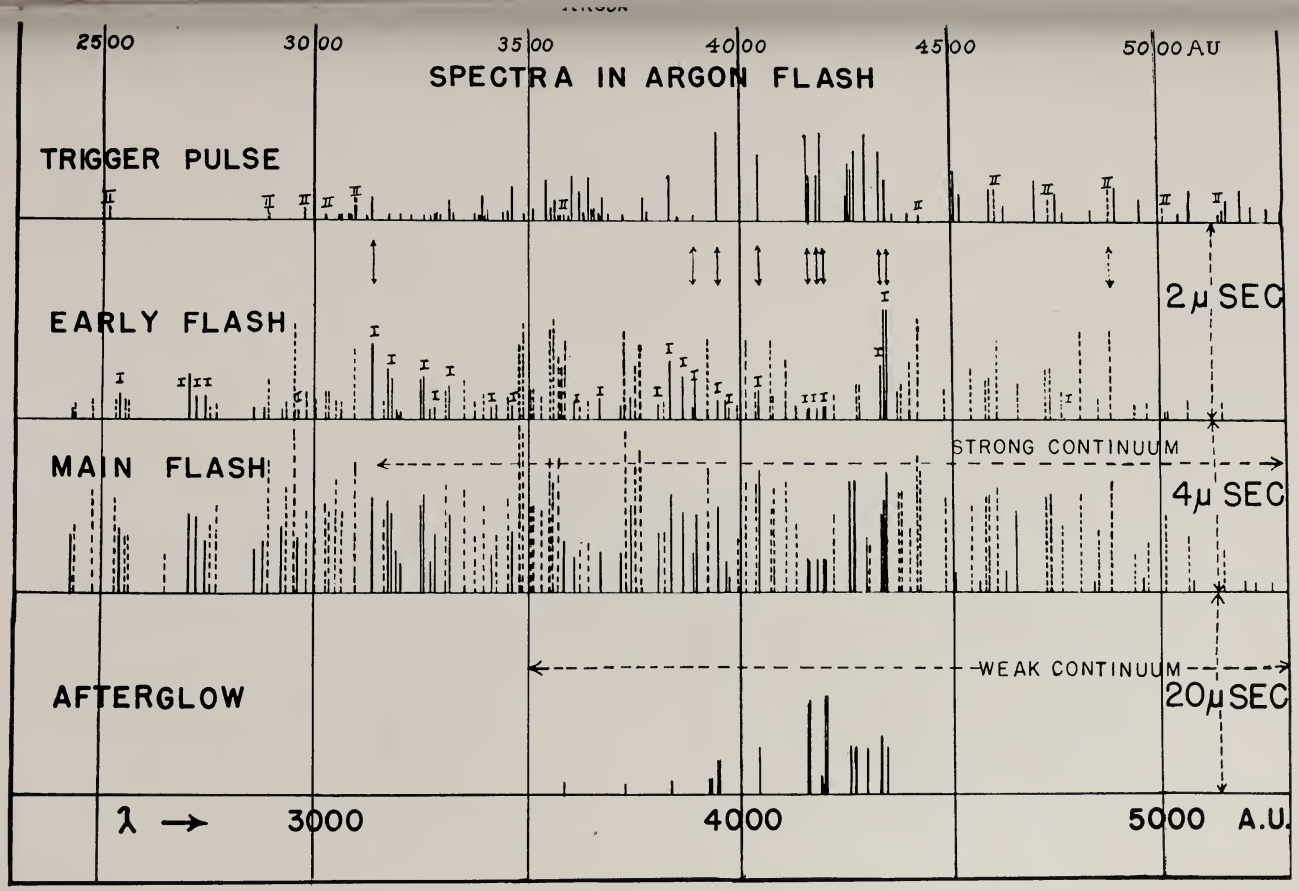

FIG. 3.—Variation in line spectra at various phases of a flash discharge in argon.

three arc lines show strongly, while twenty intense lines of the xenon ionic spectrum are identified. Similar results were obtained using other gases.

The question now arises as to how the spectrum varies with time over the entire flash period. A large number of observations were carried out using flash tubes filled with neon, argon, krypton and xenon. An example of such an analysis will be shown only for an argon-filled tube.

A method was developed for observing through a fine slit in a ten-inch disc driven by a synchronous motor, the light from the discharge at a given phase of the flash period. The particular instant in the flash when a spectrogram was taken could be varied by means of a phase changer which varied the time when the discharge was triggered with reference to the time of observation. The slit was of such a width that the observation interval was about three microseconds. Thus the emitted radiation could be photographed at any phase of the flash period in steps each three microseconds long.

Figure 3 is a chart of the results obtained using a quartz prism spectrograph. Relative photographic intensities for a given exposure are indicated by the height of the plotted lines. Solid lines are for atomic spectra (A I); dotted lines represent spark spectra (A II). The rate of synchronous flashing was one per second. However, for the weak light emitted by the trigger pulse, which occurs about 2 microseconds before the main current of the discharge begins, a higher rate was used with the discharge condensers disconnected. Thus, the exposure time for the upper section of the chart was about 300 times longer than for the other pictures. For the afterglow the exposure time was about 10 times longer than for the main flash.

The changes in relative intensities of the lines is very striking. Very few strong spark lines occur in the trigger pulse at high potential. At current peak (early flash) and at peak radiation intensity the line spectrum is predominately that of the spark, or second spectrum (II), of argon ions: some 44 relatively weak arc lines, compared to 71 spark lines of high average intensity. Late in the discharge only a few weak arc lines appear, the relative intensities of which are quite different from those appearing in the trigger pulse spectrum, or in the main discharge. The strongest set of four arc lines in the afterglow have very low intensities in the main flash relative to other lines appearing at the same time.

Conclusions

From this study of the spectral characteristics of synchronized flash discharges in rare gases the following conclusions may be drawn:

(1) The overall integrated line spectrum constitutes a small fraction ($<10\%$) of the useful light emitted by the discharge, the main radiation flux in the visible and ultraviolet regions being an intense continuum.

(2) In the short wave infrared region, measurements show that for heavy rare gases (argon, krypton, and xenon) the line spectra, consisting largely of arc lines, contributes about half the total light flux.

(3) The characteristic lines observed at the instant of peak radiation intensity are predominately those of excited ions, indicating the existence of a plasma having a high degree of ionization. Calculations

show that in the discharge column from 80 to 90% of the atoms may be ionized.

(4) The spectrum of the trigger pulse, excited when a 10,000 volt potential is suddenly applied to an external electrode, shows that high fields do not necessarily excite a strong spark spectrum. *Rather, a strong spark spectrum is characteristic of the high current, low voltage arc phase of the spark discharge.* Recent observations in high current steady arcs verify this conclusion.

(5) The presence of only atomic spectral lines in the afterglow indicates the absence of impact excitation at low electron temperatures. Here the lines arise from electron-ion recombination only, the relative intensities being characteristic of this process and quite different from those shown during the high-temperature phase of the discharge.

OPTICAL AND PHOTOGRAPHIC TECHNIQUES FOR THE SMALL-SCHOOL LABORATORY

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University of Illinois, Urbana

Most small schools and laboratories have more problems than money; this is often true of the large universities as well, but the small school is more handicapped when some special problem comes along because there is usually less likelihood of procuring equipment by interdepartmental exchange or loan. It is for this reason that the methods to be described are directed principally at the small school or laboratory.

It is rather remarkable that purely photographic measuring methods have not been more widely applied in research. Of course, there are many applications of photography in common use—to record images with the camera, shadowgraphs with the X-ray, spectrograms, and the like. However, the use of the photographic emulsion as a measuring element is still not extensive. Yet it can measure light-intensity, color, or any magnitude which can be expressed as either of these. It can measure things that the eye cannot see; and it can be applied to observe and record more closely, more accurately, and for longer periods than any individual observer.

The more flexible techniques of photographic measurement have been largely neglected; it is these that I want to describe today. There are a great many of them, and in the time allotted to me I can mention only a very few. I have chosen some which are more than usually varied, and which are especially susceptible to modification to other uses.

The motion-picture camera is often used to observe and to record the deflections of instrument pointers during tests; it is especially convenient for such things as aircraft tests, where the camera periodically records the indications of the entire instrument panel, and the films are later read visually. Prosperous laboratories often use recording oscillographic cameras to take down the data on electrical circuits. An early method of recording quantities with photographic means is shown in figure 1: a pointer-type instrument (which might be an electrical instrument, a pressure gage, or any instrument with an indicating pointer) which has had an opaque vane attached to its pointer and a light source so placed that the band of light passing through a slot in the dial is obscured by the vane as the pointer moves. The type of record produced is indicated on the slide—although of course the pattern does not show until the photographic paper or film is developed.

A record of this kind, or any variable-width record, is easily subjected to frequency or harmonic analysis. In many problems the periodicity of the magnitude being measured is important; the daily variation in earth-currents, the behavior of the tides or waves, the temperature variations in organisms, and many other phenomena are most interesting because of

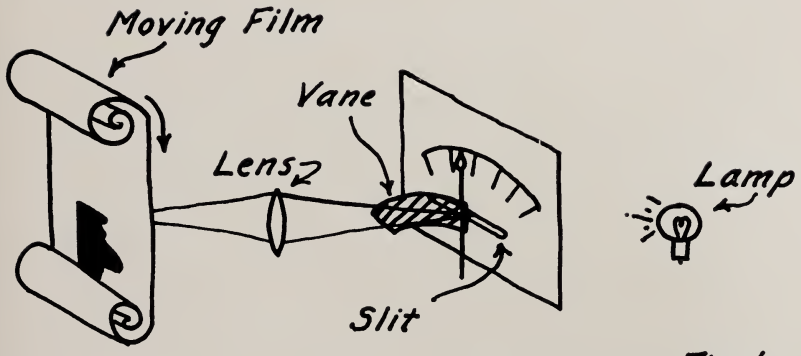
Moving Film
Vane
Lens
Lamp
Slit

Fig. 1

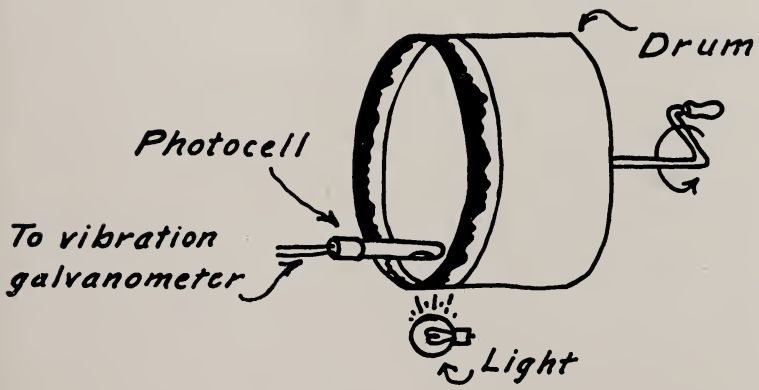
Drum
Photocell
To vibration
galvanometer
Light

Fig. 2

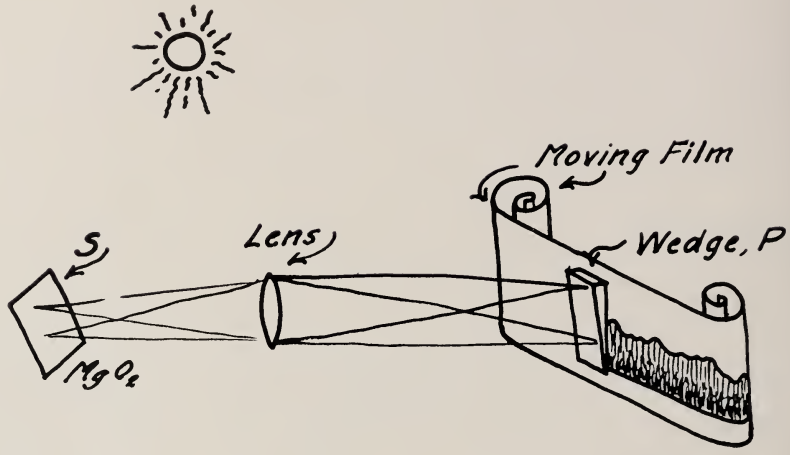

Fig. 3

their time-rate of change. Such a film record, taken over a period of days or even weeks, can easily be analyzed to determine what periodic variations may be present. It is only necessary to attach the strip of record to the edge of a cylinder which can be rotated (see fig. 2) while a light shines through the record and upon a photoelectric cell. The output of the photocell is then applied to some frequency-sensitive device; a tuned vibration galvanometer is ideal. When the speed of rotation of the cylinder is such that some component of the record comes by at intervals corresponding to the period of the galvanometer, a deflection will occur, and simple arithmetic is enough to determine the period of the phenomenon. Then other speeds of rotation can be tried until all frequency components desired are measured. Vibration galvanometers are not so common as they once were, but good results can be had with a simple tuned circuit and a vacuum-tube voltmeter or a cathode-ray oscilloscope, and these are becoming quite common in our physics laboratories.

This simple system is capable of many applications; there is a modification by which the periodic components may be evaluated by purely photographic means, but it is usually less convenient than the one mentioned. These systems, however, are only simple forms; they do not use the photographic materials in their most favorable manner.

In the following figures, there will be shown two sets of apparatus for recording sunlight and its characteristics; one records the average effective intensity, and the other both the intensity and the spectral composition or the color. The two pieces of apparatus were originally intended for use together, but can be used as individual items for their own purposes.

The first of these units (fig. 3) is for recording the effective intensity of daylight, continuously. It employs a clock-motor which moves a strip of 35 millimeter film at a rate of about 2 inches per day. Light

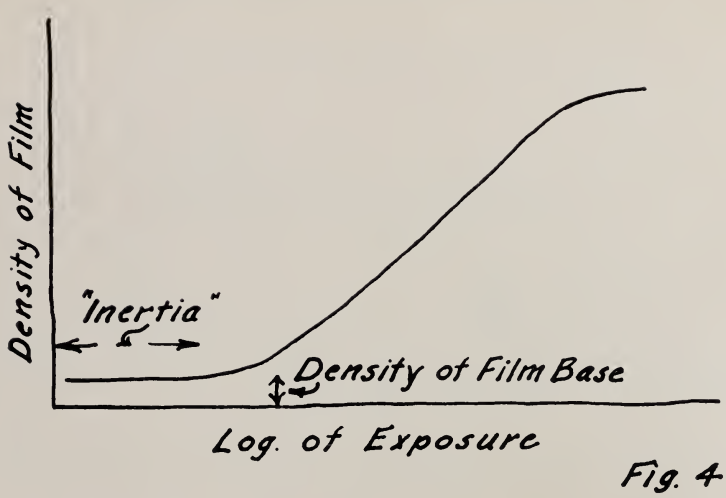

Fig. 4

from the sky falls on the surface S, which is of magnesium oxide, a neutral reflector; this light is reflected through the lens and through the gray wedge P_1 to where it falls on the film. The amount of light reaching the optical system depends of course on the intensity of the daylight, but the amount reaching the photographic film depends not only on that intensity but also on the density of the gray wedge. The over-all effect is that at some point along the length of the wedge the light intensity will be just enough to cause the beginning of darkening of the film. On one side of this point there will be perceptible darkening; on the other there will be no darkening. If a high-contrast film is used, this point is quite definite. A time-scale may also be applied to the film if that is desired.

Some of these things should perhaps be amplified before we go on to the next item. As most of us know already, the density of a photographic film (within its normal working range) is roughly proportional to the logarithm of the exposure. Below the working range there is an area where not enough light has fallen to produce a useful image. Actually, a certain amount of light must be received before any effect at all is produced; above this value the effect is proportional. This is called the "inertia effect" of the film, and it is this inertia or threshold point which is seen on the variably exposed film.

In figure 4 there is a curve showing the general shape of a density-versus-exposure curve for a film. What this means on the record is that the threshold point wanders across the film as the light intensity changes, and the boundary between clear film and gray film shows by its position the light intensity. It would be possible, of course, to permit the film to darken uniformly across its width, and to read its density with a microphotometer, except that most of us cannot afford a microphotometer. This system, in any case, makes a longer range of measurement possible.

The gray filter wedge used here is usually a piece of photographic film which has been partially exposed and developed; the exposure

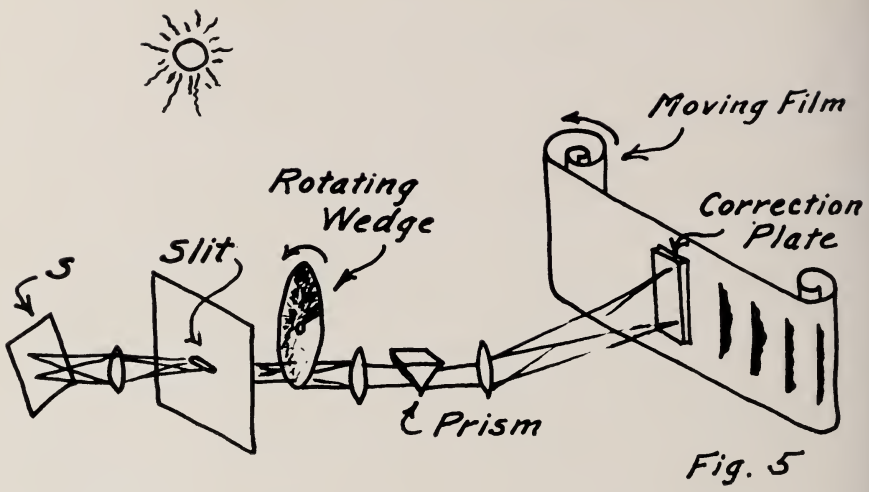

Fig. 5

is varied so that at one edge the wedge is clear and at the other edge quite dark. A density range of 0 to 3 corresponds to a range of 1000 to 1 in the amount of light transmitted. These filters can be made of gelatin, by squeezing a wedge of dyed gelatin between two thin glass plates, if neutral dyes are available. It is not difficult to make photographic wedges, but it is necessary first to prepare a curve like that in fig. 4, and then take data from it to calculate the exposures for the wedge. In all these procedures, conditions of exposure and of development must be controlled with some care.

The equipment for recording the color of sunlight is a little more complex. Again a clock-motor is used to drive the film, at about 2 inches per hour, but here a prism is used to spread a spectrum across the film, which must be panchromatic—approximately equally sensitive to all colors. The density of the various parts of the resulting band indicates the spectral composition.

To read this record, some device for measuring film density is required. The wedge method can be applied here; an easy way is to place a circular wedge over the lens, and rotate it about 10 revolutions per hour. This causes a uniform variation of intensity from very low to high, repeated every 6 minutes. The result is a series of repeated patterns along the film; the length along the film of the various elements of the pattern indicates the various intensities. The kind of pattern produced is shown in the figure; the actual films are easily read, but do not project well.

For ease in reading these records, it is desirable to equalize the frequency response, or the color sensitivity, of the film used. In figure 5 there is indicated a "correction plate" near the film plane. This plate equalizes the color response of the film. It can be made to match almost any commercially available film.

The actual response of a film to color is seldom uniform. Figure 6 shows a typical response curve; it is more sensitive to blue than the normal eye, and is also more sensitive to red. But within this range, the response may vary as much as 40

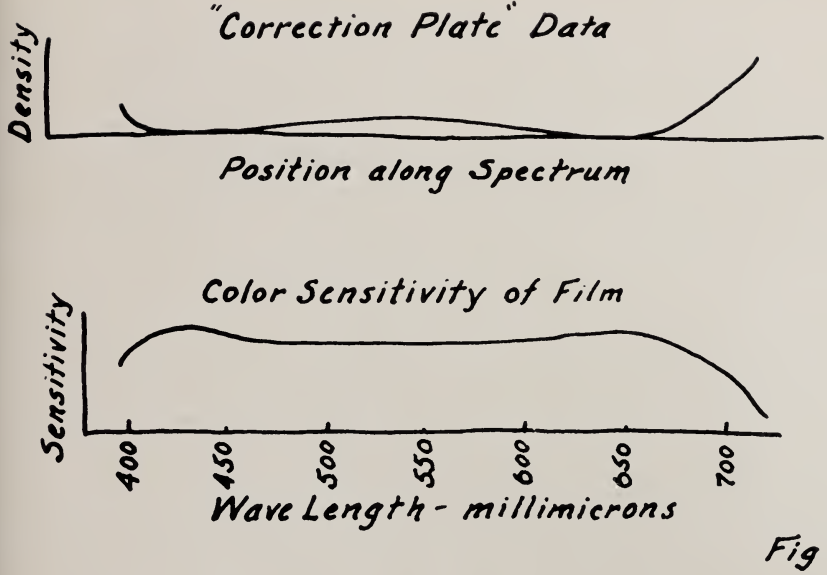

Fig 6

percent. This variation in response can be equalized by preparing a neutral density plate which matches the color curve for the film—that is, in the green, where the film is least sensitive, the correction plate permits most light to pass, but in the red range where the film is most sensitive, it cuts down the intensity. At any point, the sum of the two curves should equal the sum at any other point. The correction plate is placed close to the film; it is a neutral density filter, and its densities are adjusted according to the position of the color in the spectrum produced by the prism.

The optical quality required in these instruments is not very high; good results may be had with surprisingly crude optical systems. Reasonable care is required to avoid diffraction and reflection in unwanted places. The diagrams shown in the figures do not contain all the desirable operating details, such as the cylindrical lens just in front of the film in every case, but these details are obvious when construction is attempted.

The final accuracy to be expected from an instrument of this kind is not especially high, perhaps 5 to 10 percent. This is adequate for many purposes, particularly biological and agricultural studies. The range of intensities which can be recorded is extremely large; it is easy to handle a ratio of 10,000 to 1 because of the logarithmic scale. The actual method must of course be matched to the problem.

There are many other methods which might be described, such as force measurement either by Newton's rings or by the total-reflection method; the use of the Dove prism to extend the time range for recording with the cathode-ray oscilloscope; the photographic record from liquid-filled thermometers or manometers; and other types and classes of measurement. But these cannot be discussed in this paper: the few which have been selected will have to serve as examples of instances flexible enough to be applied in many other problems.

PSYCHOLOGY AND EDUCATION

VALIDATION BY MEANS OF THE SOCIOGRAM OF A TECHNIQUE FOR PROMOTING SOCIAL ACCEPTABILITY AMONG ELEMENTARY SCHOOL CHILDREN

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Greenville College, Greenville

There is a growing emphasis both in educational literature and in practice upon social adeptness as a primary objective of education. Pressey and Robinson express this point of view in *Psychology and the New Education* when they say that "the guidance of social development along healthy and desirable lines might well be considered the first concern of modern education and the almost complete neglect of this problem the outstanding weakness of the traditional school."

All development is, of course, continuous, and social development is no exception to the rule. Yet the study of the child has clearly shown that certain developmental tasks belong specifically to c e r t a i n age ranges. In fact, without the successful completion of these various developmental tasks sequentially, whether they are physical, emotional, or intellectual, the child is tremendously handicapped in the process of growing into a balanced adult.

One of these developmental tasks that ideally is spread over the period of time from the entrance to school at the age of six till adolescence is the emancipation of the child from the circle of the family and his entrance into his peer group. In this new world to which the child goes it becomes increasingly important to him to find a place for himself where he belongs. In fact, it is a corrolary of the social adeptness objective of elementary education that the child can develop social adeptness only in a group where he is an accepted and contributing member. For the psychologist believes that the psychological environment of the child —the reaction to him of individuals and groups with whom he is in contact—is of infinitely more importance as a factor in his development than the physical environment in which he lives.

Grouping has generally been a tool that the elementary school of our age uses to promote its intellectual purposes and to aid in reaching such goals. But whether or not grouping is a tool for the school to use in achieving its social goals and especially whether *the type of group* is a major factor in the degree of success the individual achieves as he strives to attain status are problems not yet thoroughly investigated.

It is the hypothesis of this study that through considerable use of small informal flexible groups the child who is a fringer or an isolate can most easily be helped to gain in social acceptability and, as he does this, it is believed that he will be a better achiever intellectually.

This study makes no pretense at being a controlled educational experiment. It is rather a problem in teacher education in which all the teachers at a given grade level in

a small city in southern Illinois cooperate in an attempt to help children in their groups who lack social status to attain a higher degree of social acceptability.

It is an attempt, likewise, to put in the hands of the teachers a tool by which each may discover for herself whether or not she is succeeding in helping children who have not yet attained and do not know how to attain status in their peer group. Also, we believe it will throw some light on the effect of different types of groups on growth in social acceptability.

However, since the emphasis was to be teacher education, no attempt was made to force consideration of this problem until attention turned there naturally. As it happened, for several weeks other problems occupied the focus of attention.

The background for this study is laid in the work of J. L. Moreno and dates back about fifteen years. It was in 1934 that Dr. Moreno published his epochal book, *Who Shall Survive?* In this work he developed a science of sociometry—a way of measuring interpersonal relationships in a group—and used the sociogram as a way of recording and making graphic these relationships. Since that time Helen Hall Jennings and others have used the same technique to measure social relationships within a schoolroom.

Dr. Moreno used his new discovery not only as a means of measurement but also for therapeutic purposes. In his book he described the use of it in grouping girls in cottages in the New York State Training School for Girls at Hudson, N. Y., and reported substantial reduction in number of problem cases when groups were formed on the basis of information obtained by a sociometric test.

Fifth grade children were used in this study, since previous studies have shown that social relationships among younger children are very unstable. Reading was chosen as the special field for study because the capacity of social and emotional factors to affect a child's performance, while evident in most learning situations, is especially evident in the acquisition of reading ability. This is true at least partially because the attainment level in reading significantly affects every other type of subject matter. It is also true that society puts an especially high premium on reading skill in the child.

In the small city where this study has been carried on there are seven fifth grades with an average enrollment of thirty pupils each. All teaching, heretofore, had been conducted with an entire grade group with uniform assignments for every child.

The superintendent stated in a meeting of fifth grade teachers before the opening of school that the director of the study would be at the service of the teachers as consultant, that she would teach classes when requested to do so, and work with teachers either as individuals or groups in their attempts to meet pupil needs. Such supervision as would be given would be unofficial and would be actually educational leadership emphasizing in-service training of teachers. From the beginning, largely perhaps because of the confidence of the teachers in the superintendent and because of his evident interest in, and wholehearted backing of, the study, they accepted the offer of unofficial assistance in teaching problems with

little evidence of the resistance or even resentment with which supervision is sometimes met.

When the California Mental Maturity Test was given to all fifth grade children at the beginning of the school year, it showed a wide range of ability from school to school and within schools. Two groups had median IQ's of 110 and a range of points that exceeded 60. Four had median IQ's of 102-104 and a range of 50 points, and the seventh school had approximately the same range as the last four but a median from 13-15 points lower (89) than the four average schools.

On the basis of this wide spread of abilities the seven fifth grade teachers discussed individual differences and ways of meeting them. At this stage it was evident that most teachers were primarily absorbed with intellectual differences, but it appeared even then that at least one teacher was greatly concerned about emotional and social differences in her group.

When grouping was proposed as a way of meeting differences, it was decided to make a study of some attempts in this direction to see what light they might throw on the situation. Ability grouping and interest grouping both had advocates, but some teachers showed reluctance to shift from their old one-group procedure. It was agreed that each teacher in conference with her principal would decide which procedure to follow and report at the next meeting.

The report was as follows: Two teachers—one of a superior group and one of a near average group—decided to continue to use the grade group only, with uniform assignments for all, and attempt to provide for individual differences with directed out-of-school reading. Two other teachers—one of an average group and the other of the low group—felt that ability grouping in reading with material selected for each level so that each group would be able to read without strain would best help children to develop in reading skill.

The remaining three, while not experienced in interest grouping, were eager to try a procedure in which small informal flexible groups would function frequently.

By this time the Progressive Achievement Tests had been given to fifth grades and the results were available for all teachers.

Teachers of ability groups had decided to use only two groups. Children with a reading grade score of 4.5 or less would be provided with material with a simple vocabulary but with a high interest level. Others would read the basal text. Teachers using the single grade group only made use of the results to guide their children in selecting books for out-of-school reading. Those using interest groups likewise had the results of the tests at hand to help in wise selection of books.

The general plan followed by the teachers using interest groups in reading was: (1) the selection of a general subject by the group in cooperation with the teacher, (2) the division of the subject into its various phases, (3) the listing of questions to which the children wished to find answers on each phase of the subject to be investigated, (4) the election of student chairmen by the group, each to lead his group in research on one phase of the subject, (5) division into groups according to interests, (6) work in groups,

each child reading at his own level to help to answer the questions that had been listed earlier, (7) occasional meetings of the entire group to discuss problems of the grade as a whole, see a movie pertaining to the general subject, or evaluate progress, and finally, (8) some kind of pooled summary of the results of the research.

As each teacher followed her own procedure there developed a growing concern for the social development of pupils. Some study of Moreno's sociogram was made and the teachers decided to try a special modification of it as a means of measuring social status.

The three questions finally selected for the sociometric test to be used were by no means the only ones that might have been used and not necessarily the best ones. It was decided to use one question of a purely social character. "If your mother told you you might invite a child from your room home with you to dinner on Friday night and then to a basketball game, whom would you ask?" First choice, second choice, and third choice were called for.

The second question was on an academic basis, but called for cooperation between two people. "If you need help in arithmetic and the teacher, being busy, tells you you may ask a child in the room to help you, whom would you ask?"—again, first choice, second choice, third choice. The third question had to do with ability to fit into a group and contribute to the cooperative thinking and effort of the group. "Whom do you like best to have working on a committee with you?" In each case, as above, the child was asked to give first choice, his second if the first were absent, and his third if both the first and second should be absent.

There are some respects in which it may seem regrettable that the sociometric test results could not have been procured earlier in the year. However, since this study has been conceived as primarily one of teacher education, it has been a guiding principle not to use any procedures with the groups until the teachers were ready for them. Consequently school had been in session more than three months and each teacher had had in operation her chosen plan of grouping in reading for from 6 to 10 weeks before the first sociometric test was given.

The serious approach of the children themselves to the test and their whole-hearted cooperation in answering the questions was a matter of note. All seven groups had been taken into confidence as to the year's work to the extent that they knew their teachers and the director of the study were working together to try "to find out some better ways to work with boys and girls" and they referred to the sociometric test in that connection in discussing it, though they had been told that their teacher hoped that the answers would help her in trying to make them happy in their school home.

The teachers' meeting in which each teacher studied the sociograms showing interpersonal relationships in her own group was the most interesting of the year. Varying teacher attitudes were plainly evident. At least one showed a defensive attitude at first—"Some children just don't have what it takes." Another teacher noticed one girl, who showed up distinctly as a fringer, who she felt could be helped to attain status with her peers if given

a chance to help others in arithmetic. Another commented that she believed one boy would have been either an isolate or a fringer before he worked in a small group that prepared an Indian play to show the large group what they had found out about how the Indians of the Southwest lived.

Each teacher studied with interest the group of children who were lowest in social acceptability to try to decide what the cause was and what direction remedial work should take in each case. Each teacher agreed to try to find something each isolate or fringer could do well and see that he got praise for it. Each teacher also agreed to try to build up the ego of neglected children by giving each some responsibility. The question at this point was, "Would a child rise in social acceptability with his peer group as he appeared to rise in acceptability with the teacher?"

A survey of the sociograms taken showed that there was great difference in interpersonal relationships within the different groups at that time. The only sociogram showing a group where no child was completely neglected was one of the schoolrooms where small-group work had been frequently used in the entire program for ten weeks.

Perhaps it should be noted that this school had at least one problem in social acceptability that no other school in the city faced. A children's home that had operated in the city for years moved the first of October so that it was within the bounds of this last mentioned school district and four children joined the group from the Home. This teacher used considerable ingenuity in creating situations that would help the rest of the group to realize that boys and girls from the children's home were perfectly normal children like themselves. She arranged with the director of the Home to have some committees meet there on Saturdays. Since no child was allowed to leave the Home after dinner at night except by special arrangement with a responsible adult, she arranged at different times to have a parent of one of the children in the room call for one of them and take him along with his own child to a school program or basketball game. It is probably not assuming too much to say that the very satisfactory showing of these children on the first sociometric test can be attributed to these wise procedures, for there were many indications in the first days after these children joined the group that the others did not accept them without reservations.

The second sociometric study was made April 20. In order to be able to draw conclusions about changes in degree of acceptability, it was decided to weight the choices, giving six points for a first choice, three points for a second choice, and one point for a third choice. The small amount assigned to a third choice is justifiable because experiment has shown that the third choice is far less reliable than the other two. Most children will repeat their first and second choices if given a chance to choose again soon after the first opportunity, but will vary the third choice.

The short period of time since the last sociograms were made does not permit a full analysis of results, but such analysis as has been made indicates that there is a distinct difference in the changes in acceptability in the different groups.

Rather arbitrarily we have accepted ten as the dividing point among the scores of social acceptability.

Table 1.—Number of Isolates and Fringers in Each of Seven Fifth Grades in Which Varying Group Procedures Had Been Used Throughout the Year.

School	Number enrolled	Median IQ	Range of IQ	Type of Grouping for Classroom Activity	Number with Social Acceptability Score Below 10					
					December 1			April 20		
					Isolates Score 0	Fringers Score 1-9	Total Score 0-9	Isolates Score 0	Fringers Score 1-9	Total Score 0-9
1	32	110	73-145	Entire grade.	3	4	7	4	5	9
2	27	102	78-127	Entire grade.	0	7	7	2	6	8
3	26	104	73-128	Small flexible groups.	0	7	7	0	5	5
4	30	110	76-139	Small flexible groups.	1	8	9	1	5	6
5	28	89	63-115	Ability groups....	2	6	8	2	7	9
6	32	103	72-140	Small flexible groups.	1	8	9	0	7	7
7	34	104	73-128	Ability groups....	1	9	10	1	12	13

Those receiving less than ten points are either isolates (with zero scores) or fringers (with scores from one to nine). A score of ten means that a child has received one first choice, one second choice, and one third choice, or equivalent, whereas three times that many—three first choices, three second choices, and three third choices—would be the average each child would receive on the three questions of the test if the choices were evenly distributed.

The accompanying table indicates the status of each group at two different times during the school year, as revealed by the two sociometric tests. These groups are not matched. Many varying conditions affect each of them. The main objective has been to make teachers conscious of children's needs with respect to status in their peer group, and to interest them in trying specific ways of meeting those needs.

The rough data as it stands from seven unselected groups in the same community would appear to throw some light on the usefulness of small flexible groups to promote social acceptability among isolates and fringers.

Although the evidence is not overwhelming, there is an indication here that schools 3, 4, and 6 are improving social relationships by reducing the number of isolates and fringers. These schools are the schools that have made frequent use of small flexible groups. The increase in number of children with low acceptability scores in the other groups may be due to strengthening of clique lines where no special measures are used to change the situation.

There is nothing here to suggest that there is any distinct difference between ability grouping and the grade group as a tool for affecting social relationships. All groups have doubtless benefited by their attention to this problem. But it is evident that it takes more than attention from the teacher to cause a child to rise in status with his peer group.

While the success of such a program as this should never be judged in terms of what happens academically, it will be a matter of more than passing interest to discover whether the children who have improved in social acceptability may not also simultaneously have become better achievers intellectually.

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A STUDY OF COLLEGE SCIENCE COURSES DESIGNED FOR GENERAL EDUCATION

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This investigation was begun in the spring of 1948 and completed in the spring of 1949. It has been sponsored by the Cooperative Committee on the Teaching of Science and Mathematics of the American Association for the Advancement of Science.

The purpose of this study was to determine the status, trends, objectives, content, procedures of instruction, problems, and values for general education of college-level science courses which are especially designed for students who desire a general and not specialized training in science. Many of these courses have previously been designated by such terms as survey, generalized, orientation, integrated, or foundation. All of the above-named types of courses have had in common the inclusion of subject matter from more than one specialized field of science. In addition to these courses, the study includes single-subject courses that have been modified for the purposes of general education. All types under investigation are herein referred to as *general education science courses.*

In order to secure information on the types and prevalence of courses, an inquiry was sent to the administrators of 967 four-year colleges, universities, and teachers colleges in the United States. Replies were received from 660 schools. In addition, a survey of 600 college catalogs gave information concerning 60 more schools. Thus, information is available from 74 percent (720 schools in all).

To secure detailed information about the specific courses designed for general education, a seven-page questionnaire was sent to a selected group of 300 science teachers. Usable course descriptions were received for 150 courses distributed among 103 schools of all sizes.

The data supplied on the questionnaires were supplemented in a number of ways. For many courses either outlines, syllabi, textbooks, or published articles were available for study. Furthermore, the writer investigated by personal visits 28 of the 150 courses that were studied. A student opinionnaire was administered to 1200 students in 14 courses.

Of the 720 schools for which information is available, 59 percent offer some type of general education science course. Most of these schools offer courses that cover both the physical and biological sciences, although there are some that neglect one area or the other. General education science is much more prevalent in teachers colleges than in other types of schools: it is offered in over 80 percent.

A comparison of these figures with those of pre-war studies shows that g e n e r a l education science courses are now much more widespread than at any previous time. They have increased in number

rapidly in the post-war years. Furthermore, a majority of the schools that do not have general education courses appear to be interested in developing them.

Of course, there is some opposition to this trend. The most obvious reasons are the satisfaction with the regular introductory science courses for purposes of educating the non-science major, and the difficulty of securing qualified teachers for the newer courses.

Ninety-two percent of the courses are planned specifically for the freshman and sophomore years. About half the colleges require one year of science of the general student. The remainder require more, usually two years. Most schools require work in both the physical and biological sciences.

In classifying courses on the basis of content, four principal types are revealed: (1) the general courses which include materials selected from all the areas of natural science, (2) the courses including subject matter selected from the fields of physical science, (3) those with material from biological science, and (4) the courses in single subjects, as physics or botany. Few new courses of the first type are being organized. The single-subject courses are multiplying more rapidly than the other types, especially in the large universities. However, there are fewer of these courses than any of the other types.

The common methods of subject-matter presentation are, in their order of frequency: (1) the survey of the subject matter of the area covered, (2) the more intensive study of selected units from the subject matter area, (3) the study of selected problems, and (4) the historical approach.

In the 103 schools offering the 150 courses that have been studied in detail, the average enrollment in general education science was approximately 400 students per school in 1947-48. This represents about one-third of the freshmen and sophomores. In separate schools the number of students that take the courses varies from a small group to 100 percent of the students.

Individual course enrollments in 1947-48 ranged from as few as 8 to more than 4000 students. The largest enrollments were in the biological science courses; the smallest were in the single subjects. There was a somewhat larger percentage of men than women enrolled in the courses.

Approximately 75 different objectives were reported for the courses. Of these, 7 are especially prominent. They are, in the order of frequency of mention:

1. To develop an understanding of the scientific method and facility in its use.
2. To provide acquaintance with, or mastery of, the leading principles, laws, and concepts of science, particularly those that have a bearing upon the daily life of the individual.
3. To provide a core of scientific knowledge or to give a broad understanding and general knowledge of science.
4. To develop various scientific attitudes of mind and appreciations of the values of science.
5. To give an insight into the relationships between science and the problems of living and to develop the ability to apply scientific knowledge to the solution of these problems.
6. To develop a greater joy in living through a more complete un-

derstanding and appreciation of the natural environment.

7. To stress cultural aspects of science and to show how science has contributed to civilization.

A majority of the teachers reported clearly defined objectives that are compatible with the main purposes of science for general education. However, in some courses there were apparently no special objectives beyond the desire to teach science.

The most frequently used methods of determining subject-matter content are, in order of prevalence:

1. Determination of the needs of the students.
2. Selection of a textbook.
3. The interests of students in the class.
4. To survey a field of science.
5. Analysis of the objectives and how to accomplish them.

The subject matter of the biological science courses varied widely, as did that of the physical science courses. There seems to be no ideal content for a general education course in science. Teachers have yet to agree upon any one common core of factual material, or upon a uniform method of presentation. Probably neither is to be desired.

Although many of the teachers in charge of general education courses are scientists and educators of note, a majority of the teachers in the courses do not have a Ph.D. degree and are in the lower professorial ranks. Twenty-two percent are assistants with no rank. Only 40 per cent are employed specifically for general education and only 30 percent devote full time to this work. Ninety-one percent of all teachers are specialists in one or another of the fields of science. Very few received college training designed to prepare them for teaching general education science.

In considering the common characteristics of the courses, we find that the typical course is one year in length and offers three credits per term. It is given by two or more teachers who use demonstrations, visual aids, field trips, and laboratory exercises in addition to lectures and discussions.

The most important problems that arise in giving general education courses are concerned with procuring teachers, providing suitable laboratory experience, securing acceptable textbooks, and selecting and limiting the subject matter.

There is considerable but not universal enthusiasm for the general education type of science course. In schools where such courses exist, the administrators, above all others, favor them. The courses in most schools were inaugurated by deans or presidents.

Among college faculties opinions vary from energetic advocacy to definite antagonism and from strong interest to a complete lack of understanding of the nature of general education.

A large majority of the persons who teach in the courses like them and work diligently to make improvements. Some teachers have been assigned the courses against their will; in the main, these teachers are subject-matter specialists whose interests lie in their specialties. Also they feel that they are inadequately prepared for teaching in a broad field of science.

Among science teachers there are some who oppose the general education courses because they take students away from their own speci-

alized courses. On the other hand, there are those who believe that the general education courses are an excellent means of interesting students in following a scientific career.

There is a tendency for some scientists to look down upon the courses and their teachers. This attitude may have been justified in former years when the courses were sometimes elementary and superficial, and the teachers poorly prepared. Although these conditions still exist, they are not common. Most of the courses are well developed and many of the teachers rank among the best.

The teachers report that most of the students like the courses. Various student appraisal studies corroborate this viewpoint. However, there are some students in every course who dislike science or find it difficult.

In the student opinionnaire investigation, 77 percent of the students rated the courses above average in the choice and use of the instructional materials and procedures. Seventy-five percent said the courses were above average in imparting useful information. Fifty-six percent rated the courses above average in making a positive contribution to their college education.

Most of the students were enthusiastic about their teachers. Eighty-eight and 85 percent respectively rated their instructors above average in knowledge of subject matter and in enthusiasm for their courses.

In general, the courses, the procedures of instruction, and the teachers were given a high rating. The conclusion must be drawn that a large majority of the students believe the courses to be highly satisfactory.

General education science is rapidly occupying a position of importance in college curricula. It is growing in prevalence, popularity, and respectability. Ambitious young science teachers can expect to look to this field for a career that will offer the same rewards as a teaching career in one of the separate sciences.

In this relatively new area of science teaching there is a tremendous challenge to teachers to perfect techniques for presenting science to the non-scientist. On all sides the challenge is being met by teachers who are improving old procedures and experimenting with new ones. From their efforts are coming methods that will be of value in all types of science courses.

General education science is firmly established and widely accepted. We can confidently expect that in the near future there will be an even greater extension of the courses in American institutions of higher education. In this scientific age, we can look forward to an increase of literacy in science that will benefit both the individual and society and smooth the path for the progress of science.

SOCIAL SCIENCE

SOCIOLOGICAL PROBLEMS IN THE STUDY OF INDUSTRIAL RELATIONS IN ILLINOIS

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The problems and areas of research discussed in this paper are the result of my own experience and reflection in the past three years, during which time I have been a sociologist on the staff of the Institute of Labor and Industrial Relations at the University of Illinois. The research carried on there has involved the collaboration of economists, political scientists, psychologists, and sociologists. The problems which I discuss are influenced by these related social sciences and may appear at first glance to be rather foreign to sociology as it is commonly understood.

Careful studies in the sociology of industry are a new development which has come about since 1940. There is still a great deal to be settled about the relationship of this new area to the older branches of sociological theory. It is not my intention at this time to go into this somewhat academic matter, but rather to point out a few of the substantive areas of investigation which seem to present promising lines for empirical research.

In speaking of industrial sociology in Illinois, I am referring specifically to the down-state or non-Chicago region. I do this for two reasons: first, Chicago is relatively better known through earlier research and is currently being studied by Northwestern University and the University of Chicago while the University of Illinois is the only institution (that I know of) which is studying the smaller cities and the rural areas; second, the Chicago area is so different in size, in population characteristics, and in the development of industrial relations that it is best treated as a separate category. What I have to say, therefore, is intended as a guide to those persons who may be interested in the sociological aspects of business and industrial relations in the down-state region.

Before one can assess the importance and magnitude of these problems, it must be understood that the entire character of the down-state region has been rapidly changing in the past three or four decades. Many people still think of the Chicago—down-state distinction as primarily a difference between a large city and a rural district; but this is no longer true, since a majority of the down-state population are town dwellers. This majority is increased if we add to it the large number of persons who live in the country but make more than half their living in some nearby town, and are therefore economically dependent upon manufacturing or commerce more than upon agriculture. The growth of cities like Decatur, Peoria, and Rock Island has produced the same kind of political and social division between city and the local country dwellers which is found on a larger

scale in the great metropolitan centers. The expansion of industry in down-state communities has resulted in the development of attitudes toward political and economic issues which are more nearly similar to those in Chicago or other big cities than they are to the attitudes in the surrounding rural areas. This has broken up the old unity of opinion which was based upon common regional interests.

While the growing similarity of all cities is of significance, there are at the same time important differences between down-state communities and Chicago which must be recognized. The relative newness of industry in the smaller cities has emphasized the difficulty of making over a town to an industrial base from the older trading center and "county seat" type of life. The rapid growth of trade unionism has similarly forced a rapid change in business practices and in community organization. This process of urbanization is still progressing rapidly and is the source of many of the so-called social problems which are currently faced by our towns and cities.

One of the topics which invites study is the organization and administration of small-scale businesses and small manufacturing establishments. We know a great deal about the ways in which large corporations conduct their operations; we know a lot about the problems of administration and supervision in mass-production factories; and we know a good deal about labor-management relations in big companies. This is in part because large enterprises naturally attract attention, and also because the large companies have recognized the need for studying their human relations problems. However, we have practically nothing concerning the hundreds of small and medium-sized companies which face comparable difficulties.

The research in this field which is now being carried on at the University of Illinois by the Institute and the College of Commerce is in a sense pioneer work; it must go much farther and must be supplemented by the efforts of other schools before we shall have an adequate understanding of the problems and practices of the small business man.

It is commonly said that one of the reasons for bad employer-employee relations is the large size of many companies. If this is true, then relations in small companies ought to be good. To date, however, we do not know if this idea is valid, and we shall not know until we have studies of many small companies. There is another reason for examining closely the sociology of the small business concern. This kind of business is probably the most seriously affected by depressions and labor turnover. Anything which will contribute to stabilizing these companies will, in turn, help to stabilize employment in general and community well-being. The sociologist can make a contribution by finding means to improve personnel practices and employee relations generally.

A closely related field of study is the nature of collective bargaining in the smaller company. Here again, we know very little. We suspect that the process of reaching agreement between union and management in a situation where owners and management are present, and consist only of one or a few persons, is quite different from the situation in a large company where the owners are absent and management is a

very large and complicated group of persons. A further complication lies in the fact that most small companies and union locals follow patterns set by the larger industries and in a sense, therefore, do not develop original or local patterns. Absentee control is important in both management and union for it reduces the independence of local representatives on both sides. In certain industries, absentee control has been carried to the point where labor contracts are made in the larger cities, and neither local employer-managers nor workers have much to say about the terms under which they operate.

Another large and important field of study is the structure and operation of trade unions in the smaller community. Organized labor has expanded greatly even in small towns in the last decade. The magnitude of this development can be seen when we consider that in many industrial towns at least half the total population are either union members or belong to the families of union members. In coal mining communities, especially, union affiliation may go as high as 90 percent of the population.

Three subdivisions can be stated within this general area of study. One is the changing attitudes in the working population, which have underlain this rapid acceptance of the union movement. This is especially important in the down-state area, which not so long ago was thought of as a non-union conservative region in which most workers reflected a rural or small-town orientation toward economic matters. The shift toward unionism is an expression of the growing urbanization of down-state people, including many of the rural dwellers.

A second approach to the study of unionism is the examination of the internal organization of unions at the local level. We know even less about the operating practices and problems of unions than we know about small business. Since the two are closely related, we cannot adequately understand one without considering the other.

A third aspect of unionism is its impact upon the social structure of the smaller community. Because of the newness of unions in most of the down-state areas the impact of their large scale organization upon the community at large has not been felt to the same extent as in larger centers where the unions are better established and more mature. However, the beginnings of union interests in community affairs can be seen in their concern with schools, local taxation, and the community chest. This interest will almost certainly expand, and the unions will very likely occupy a key position in such matters, since they are the only organizations which represent large numbers of workers, and can mobilize mass support for efforts in the civic field.

A more general problem is that of the population change brought about by the establishment of new industries and the decline of older ones. This is well illustrated by the current efforts to secure new and diversified industries in southern Illinois to replace the declining coal mining industry. In this region the only alternative to new types of employment is wholesale migration to expanding communities where there are opportunities for employment. This same problem can be found in less exaggerated circumstances throughout Illinois. It is a problem which has attracted serious attention on the part of those concerned

with the declining importance of the small trading center. There is today practically no part of the state which is not dominated commercially by a larger city. The result of this has been that many smaller towns which were based upon trade with the surrounding countryside have lost their economic base and must either decline in size and become ghost towns or find some new means for supporting their population.

The background characteristics of the down-state population are being steadily influenced by our industrialization. The area as a whole has never received large numbers of immigrants from eastern and southern Europe as has been the case with all of the cities in the East and metropolitan areas such as Chicago. There are a few special instances in which "foreign" groups have entered down-state Illinois. One of these ethnic elements is found in the Polish foundry workers who are present in almost every community where such employment is available. A second example are the Polish and Silesian coal miners who have come with the Scotch-Irish, English, and Welsh miners. Except for these specialized groups, the down-state population is a rather homogeneous combination of Anglo-Saxon and German, with a considerable Scandinavian group in the northern part of the state.

This population is being steadily augmented by migration into the area from the border states and from the deep South, of both white and Negro. The increase in the Negro population of many cities causes racial tensions and legislative efforts to stabilize the situation. Negro workers are entering industrial communities in response to the occupational opportunities presented to them. In general, they fill those jobs which are considered too low in pay or too undesirable to attract native white workers. In this sense, they are filling the position in Illinois industry which was filled by the eastern Europeans in the industries on the Atlantic seaboard.

The white migration is numerically much more important than the Negro. The wave of settlement from the border states, in particular, has now been noticeable even in the northern cities of Illinois, although it is greater in the southern part of the state. The Southern whites, like the Negroes, enter our industrial system in the lower occupations, but unlike the Negroes, the Southern whites have relatively little difficulty in moving upward into better jobs. The general acceptability of the white immigrants is highest in the southern half of the state, where the cultural differences between immigrant and native are so slight as to be of no real importance. The magnitude and continuity of the white immigration is such that if continued it will result in a new and even greater homogeneity of background of the native white population of all down-state Illinois and will quite possibly bring about a shift in the general culture toward that which now exists in the border states to the south.

The topics I have mentioned range from very specific matters of industrial relations in the small company, up to very general considerations of population changes in the state. I have brought them together in this paper because in my opinion they all represent social phenomena related to industry which can be profitably studied by the methods and concepts of sociology. In my opinion, all

these problems can be analyzed within the existing theoretical framework which sociology has established, since they all involve the common substance of human life, namely the organization of social structures, the functions of leadership and administration within these organizations, and the cultural values which people hold. A beginning has been made in the examination of each of the topics which I have mentioned, but it is only a beginning. The major part of the study lies ahead.

Every trained person, regardless of where he may be in the state, can make a contribution to one or more of the lines of the proposed research. We can accomplish an understanding of these matters only through the collaboration of many persons in many institutions throughout the state, all focusing their attention upon the common set of problems.

THE RELATIVE POWERS OF NATURE AND NURTURE: MONOZYGOTIC TWINS

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Although the "twin method of study" provides an ideal set-up for the investigation of the problem of "nature and nurture," egregious blunders have often been made in regard to the diagnosis of monozygosity.[1] A number of writers have failed to grasp the fact that it is not easy to determine whether single sexed twins are monozygotic or dizygotic. Precisely and scientifically speaking, there is only a very high degree of *probability* that some similar-sexed twins may actually be monozygotic. This degree of probability is sometimes so high as to amount almost to certainty. As everyone knows, monozygotic twins must be of the same sex since they are "derived from a single fertilized egg-cell which later splits into two parts, each developing into a complete child."[2]

The hasty investigator of the problem of "nature and nurture" is all too prone to seize upon one characteristic as a "proof" of monozygosity, thus speeding up his work but also vitiating its scientific validity. If twins are born with a single chorion, it is often assumed that this "proves" that the twins are identical. The common chorion is, indeed, an indication of monozygosity. It is not, however, a proof, because it is possible for the "chorions of two germs developing close together" to fuse.[3] Thus dizygotic twins may, and sometimes do, have a common chorion. It is almost impossible to tell at the time of birth of twins whether they are "identical" (monozygotic) "because important characters have not yet developed."[4]

In point of fact, monozygotic twins, at the time of their birth, tend to be *more* different than fraternal twins, in respect to weight and length, on account of prenatal conditions. The reason for this is quite obvious. When two fetuses develop in one single chorionic sac, one is generally in a more favorable position than the other and consequently is more advanced at the time of birth. By the time the single-chorion twins have reached adolescence, the identical hereditary set, if it actually exists, will have produced two human beings so much alike, in their physical characteristics, that they will be very frequently mistaken for each other, even by close friends, at first glance. Closer observation will reveal that the color of the eyes, the implantation of the hair, form of the skull, the color and vasculation of the skin are strikingly similar.

An interesting factor has recently been introduced into the diagnosis of monozygotic twins by the use of the electroencephalograph, an apparatus designed by Berger in 1929. It had of course long been known that the brain controls the body. Berger was

[1] See H. H. Newman, *Multiple Human Births*, New York, 1941.
[2] A. B. Fortuyn, "Modern Research on Identical Twins," *Quarterly Review of Biology*, vol. 7, 1932, p. 298.
[3] *Ibid.*, p. 300.
[4] *Ibid., loc. cit.*

the first to record, efficiently and precisely, the minute electric discharges occurring in brain cells, active or at rest.[5] These tracings are known as electroencephalograms or "brain waves." By 1935 the interest of a number of scientists was aroused by the unique problem of monozygotic twins in relation to the similarity or dissimilarity of the recorded "brain waves."

In recent years electroencephalograms have been made of a large number of fraternal and identical twins. Usually, but not always, those twins previously regarded as monozygotic, on the basis of the single chorion and other factors, showed identical "brain waves" when the "E.E.G." test was administered.[6] In the case of the XY twins, one of the pairs personally studied by the present writer, not only was there a single chorion and also, after early childhood, so marked a degree of physical resemblance that even their closest friends frequently mistook one for the other, but also a complete identity of the "brain waves" as recorded by the electroencephalograph. In such a case it is safe to assume, without violating the canons of scientific precision, that these similar sexed twins are monozygotic.

In 1938 a careful study of personality differences between monozygotic twins was published by Dr. Evelyn Troup, who selected 20 pairs of identical twins in the city of Buffalo and tested them by means of the Rorschach method. Dr. Troup, who was fully aware of the difficulty of diagnosing monozygosity, used single-sexed twins previously regarded as identical *only* if at least eight definite criteria of monozygosity were present. Although these criteria did not include the electroencephalographic recordings, it is fairly safe to conclude that the 20 pairs of twins selected were actually monozygotic. The results of Dr. Troup's experiment coincided very closely with the findings of the present writer. The sample is, of course, too small to warrant any definite conclusions along statistical lines. The value of her study lies in the individual case histories. An analysis of the 20 cases studied suggests the following conclusions:

(1) Owing to the genetic set-up, there is a basic physical and temperamental similarity between "identical twins."

(2) There is frequently a marked difference in personality structure even in two such "identical" human entities as monozygotic twins. This difference appears clearly when the Rorschach test is given.

(3) The popular stereotype of identical twins is usually erroneous. This stereotype represents monozygotic twins as an inseparable couple bound together by common interests and close ties of affection. Since such pairs attract attention at first glance, an undue importance attaches to them. Only two of the pairs studied by Dr. Troup corresponded to this popular stereotype. The remaining eighteen showed such wide variance in personality structure and interests that her conclusion was that "the total personality pictures of the members of each pair indicated in general no high degree of resemblance."[7]

In one of the pairs tested by the

[5] W. G. Lennox, E. L. Gibbs and F. A. Gibbs, "The Brainwave Pattern, an Hereditary Trait. Evidence from Fourteen 'Normal' Pairs of Twins," *Journal of Heredity,* Vol. XXXVI, No. 8, August, 1945, p. 233.

[6] *Ibid.,* p. 234.

[7] E. Troup, "A Comparative Study by Means of the Rorschach Method of Personality Development in Twenty Pairs of Identical Twins," Genetic Psychology Monographs, Vol. 20, No. 4, p. 544.

Rorschach method there was not only a marked personality difference but also a strong hostility between the two members. Both the personality difference and the hostility were quite clearly the result of "nurture" rather than "nature." Although this particular case is definitely abnormal both in the statistical and the medical sense of the term, it is worth mentioning because it uncovers the problem of antagonistic monozygotic twins, a problem ignored by Newman. Furthermore, it sheds considerable light on a feature which is nearly always found in normal family life, namely, the tendency of children to compete with one another for the mother's affection.

The mother of the eleven-year-old girl twins designated as A and B in Dr. Troup's study of personality development was, in 1934, in a New York State hospital. Her case had been diagnosed as dementia praecox, paranoid type.[8] In 1936 she was sent home, under medical supervision. The twins were living at home, together with the other seven children in the family, when Dr. Troup administered the Rorschach test. The father was regularly employed as a mechanic. Both parents were born in Hungary and had come to the United States in early childhood. The twins' mother had married at the age of seventeen. She expressed dissatisfaction with her marriage and constantly accused her husband of infidelity. During the two years of her hospitalization, the twins had been placed at first in a foster home where both made a very satisfactory adjustment. After a few months they were sent to an orphanage, where the other children had already been placed.

After the mother's release from the hospital, arrangements were made for her to visit the children. It was during this period that the differences between twin A and twin B became apparent. The Sisters reported that twin A became "jumpy" when the mother appeared. She begged to be taken home. Her school work began to deteriorate; she "withdrew into herself" and displayed symptoms which were diagnosed as possible chorea. Her request to return home was granted. Twin B remained in the orphanage for a few months longer. When both twins were home the mother reported that she had no difficulty with twin B but claimed that twin A was "nervous, had terrible dreams, and was afraid to take a bath in a tub." She quarrelled constantly with twin B and also with her younger brother. She told her mother:

"I'm the black sheep. You like [B] better."

Twin A was taken to a child guidance clinic, where the psychiatrist was impressed by her "marked feeling of inferiority, both socially and academically." His opinion was that the mother had rejected the child and tended to identify her with the mother's husband's sister who, according to the mother, was "queer" at one time. Both twins were of normal intelligence, the I.Q. tests being recorded as 101 for twin A and 107 for twin B.

The Rorschach tests administered by Dr. Troup showed a marked similarity in the temperament of twin A and twin B. There was, however, so great a difference in the emotional structure of the two girls that she concluded that this case showed "how different the quality of personality make-up in a pair of identical twins with similar basic per-

[8] *Ibid.*, p. 497.

sonality constellations''[9] may become under certain circumstances.

The Rorschach tests of twin A indicated greater ''sensitivity,'' a strong tendency to ''retreat into introversion,'' together with a ''more vital and colorful mental life'' than in the case of twin B. Twin B was adjudged, on the basis of the Rorschach tests, to have ''apparently succeeded in covering up the danger of the over-development of the whole inner life by an analyzing attitude.''[10] Both twins showed a tendency towards introversion. The personality differences were clearly a result of subtle environmental differences.

Less clear cut, but indicative of similar conclusions, is the case of the twin boys designated as K and L in Dr. Troup's study. Their age, at the time of the experiment, was eleven. Their parents were born in Germany. The father was regularly employed, and had five children at the time the study was made. The home was of average comfort.

Unlike some of the other twins studied by Dr. Troup, twins K and L were scarcely ever seen in each other's company. Twin K, who, according to the results of the Rorschach test, had passed beyond the pre-puberty stage and had entered ''the introversial swing typical of the climax of puberty,''[11] spent most of his time in the home taking care of his younger sister. Twin L, on the other hand, who was aggressively friendly and sociable and assumed all responsibility for outside social contacts, spent nearly all his time with other boys of his own age. The Rorschach tests indicated in the case of twin L the ''constriction typical of pre-puberty,'' although to a less degree in relation to his surroundings than toward his inner life. The personality divergence, as measured by the test, was mainly a matter of difference in the ''tempo of development.''[12]

In the case of X and Y, one of the pairs of monozygotic boy twins studied by the present writer, an interesting phenomenon presented itself. Both twins were ''incubator'' babies. Y (the smaller of the pair) weighed four pounds at birth, and X five pounds. The mother developed an over-protective attitude towards Y, who was slightly handicapped by deafness. The ''tempo of development'' was curiously uneven in the case of X and Y. At the age of eleven, Y was unable to read or write or to ''hold his own'' in grade school, while X was able to proceed along normal academic lines. X was aggressively friendly outside the home, while Y showed a marked tendency to retreat into a world of phantasy.

The results of the Rorschach test administered in a child guidance clinic when X and Y were thirteen years old showed marked discrepancies in emotional adjustment. At the clinic, X was definitely more cooperative than Y, who ''camouflaged'' to the best of his not inconsiderable ability in this respect. On the basis of the tests, Y was adjudged to be slightly superior in regard to abstract thinking, while X was regarded as definitely superior to Y by the grade school authorities. The competition between X and Y for the affection of the mother was intense. Removed temporarily from the over-protective home atmosphere, Y responded gradually to the educational program outlined by the clinic, while X, who remained at

[9] *Ibid.*, p. 501.
[10] *Ibid.*, p. 500
[11] *Ibid.*, p. 517.
[12] *Ibid.*, p. 519.

home with his older sibling, gradually abandoned his former hostile attitude towards Y, which had occasioned considerable anxiety in the home.

One of the most ambitious of the recent studies of monozygotic twins is the work of Rosanoff, Hardy and Plesset, who assembled the records of 1016 pairs of twins from child guidance clinics, correctional institutions, medical centers, state hospitals, and prisons. This work covered a period of ten years.[13] The authors analyzed 409 cases of "twins with child behavior difficulties, juvenile delinquency, or adult criminality."[14] Among the monozygotic twins, there were "concordant findings" in regard to delinquency or criminality in 86.9 percent of the cases examined and "discordant findings" in 13.1 percent. Since nearly all the monozygotic twins were raised together, the percentage of "concordant findings" fails to establish the thesis maintained by Lange, Stumpfl and others that a study of monozygotic twins with criminal records "proves" that there is a positive correlation between crime and heredity. Futhermore, even among the monozygotic twins where the "criminal findings" were "concordant," there were "quantitative and qualitative intrapair dissimilarities."

As a study of the etiology of delinquency, crime, and behavior difficulties, Rosanoff's study of monozygotic and dizygotic twins leaves much to be desired because of the fragmentary nature of the case histories assembled by him and his associates. Consider, for example, the history of Wendell and Donald C. These twins were born in 1907. They were adjudged to be monozygotic. The family was "highly respected in the community," the father being a practicing physician. Donald, the first born of the twins, was heavier by one pound at the time of birth. At school he was usually one year ahead of his twin brother. While Donald never "presented any behavior difficulty, delinquency or criminality,"[15] his twin brother gambled, drank to excess, and occasionally used marihuana. At the age of 23 Wendell was arrested on charges of "grand theft and forgery." Released on probation after a term of imprisonment and placed in charge of his family, his later career is unknown. While this case history reveals almost complete divergence of behavior patterns in a pair of presumably monozygotic twins, it sheds little light on the "etiology" of behavior problems. In general, Rosanoff's material fails to substantiate his preliminary statement (considerably modified in his "Summary") that his "findings were roughly in harmony with those previously reported by Lange, Stumpfl and others, as suggesting that *hereditary factors play a part in the etiology of the behavior difficulties under consideration.*"[16]

An analysis of the recent studies of monozygotic and dizygotic twins suggests the following conclusions:

(1) The "twin method of study" provides an ideal set-up for investi-

[13] Rosanoff, A. J., Handy, L. M. and Rosanoff, I. A., "Etiology of Epilepsy, with Special Reference to its Occurrence in Twins," *Arch. Neurol. Psychiat.*, Chicago, 1934, 31, 1165-1193. Also, "The Etiology of Mental Deficiency with Special Reference to its Occurrence in Twins." *Psychol. Monographs*, 1937, 48, No. 4.

[14] Rosanoff, Handy, and Rosanoff-Plesset, "The Etiology of Child Behavior Difficulties, Juvenile Delinquency and Adult Criminality with Special Reference to their Occurrence in Twins." *Psychiatric Monographs*, No. 1., State of California Dept. of Institutions, Jan. 1941, p. 182.

[15] Rosanoff *et al.*, "The Etiology of Child Behavior Difficulties," p. 47.

[16] *Ibid.*, p. 9. (Italics those of Rosanoff et al.) Cf. Stumpfl, F. *Die Ursprunge des Verbrechens, dargestallt am Lebenslauf von Zwillingen.* Leipzig, 1936.

gating the relative powers of "nature and nurture" *only* if used with sufficient scientific precision. However, many published studies have lacked this qualification and have merely supported preconceived notions of the importance of heredity or of environment.

(2) The role played by heredity has *not* been proved in behavior problems, delinquency, or crime, but there is a high degree of probability that certain organic diseases such as schizophrenia *may* be hereditary. In this latter field of study outstanding work has been done by Franz J. Kallmann in recent years.[17] It can scarcely be denied that impressive evidence has been presented by Kallmann and Rudin which would seem to indicate an inherited predisposition for schizophrenia and this evidence is corroborated by such case studies of monozygotic twins as that of Gardner and Stephens.[18]

(3) Even in this area, however, much scientific caution must be observed, while genetic "fatalism" is completely out of place. The *caveat* of Kallmann himself is of special significance. As he accurately observes:

"We may either render the given morbid gene less penetrant, or we may change its expression through carefully directed management of *vital environmental influences* or by methodological mobilization of constitutional resistance factors."[19]

(4) While no sociologist should adopt what F. J. Kallmann calls the "simple device" of denying the role played by human heredity, the importance of family environment is revealed in all careful studies of monozygotic twins.

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[17] Kallmann, F. J., *The Genetics of Schizophrenia,* J. J. Augustin, New York, 1938. See also, *Am. J. Psychiat.* 103: 3. 1946, Kallmann, F. J. and Barrera, *Am. J. Psychiat.* 98: 4. 1942.

[18] Gardner, E. J. and Stephens, F. E., Schizophrenia in Monozygotic Twins," *Journal of Heredity,* 40, p. 165. June, 1949.

[19] Kallmann, F. J. "Applicability of Modern Genetic Concepts in the Management of Schizophrenia," *Journal of Heredity,* 39, Nov. 1948, p. 344. Italics those of present writer.

THE NEED FOR CORPORATE RESEARCH IN THE SOCIAL SCIENCES

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Since the term *corporate research* is not one in general use, I shall define it at the outset. Corporate research is research carried on by a number of individuals representing different fields of specialization (or different disciplines), whose activities are integrated in terms of a general plan, are guided by a recognized leader or director, and are focused upon a single problem or complex of related problems. Although the term *corporate research* may be unfamiliar, the principle is not new. A striking example of the effectiveness of corporate research in the physical sciences is afforded by the work of the Manhattan Project in developing the atomic bomb. One reason the Manhattan Project could be set up quickly and could function smoothly was that the pattern for this type of research organization had already been worked out in the research laboratories maintained by corporations such as General Electric and A. T. & T., and many top-ranking scientists had already had experience with such organizations. Examples of the beginnings of corporate research in the social sciences are found in the work of certain foundations, notably the Russell Sage Foundation, the Scripps Foundation, and the Twentieth Century Fund, and in some of the work carried on by the Bureau of Agricultural Economics of the U. S. Department of Agriculture, also the Food and Agriculture Organization of United Nations.

Corporate research is differentiated sharply from *individual research* —the prevailing form of social research today—in which the individual selects his problem, formulates his hypothesis, determines methods of investigation, gathers his data, and writes up his findings, hoping of course for publication and perhaps professional advancement. Indeed, there are grounds for suspecting that a large part of the individual research now being done in the social sciences is motivated by this hope rather than by an insatiable thirst for knowledge. Consider, for example, how many academic persons find that their thirst has been permanently slaked after their Ph.D. dissertation has been accepted! The shortcomings of individual research were indicated recently by Professor Harold W. Saunders, in reporting on a census of sociological research in Midwestern colleges and universities, when he declared that "most of the research is still highly *individualized endeavor,* carried on as subsidiary to the function of teaching, is short run and piecemeal in organization, and is poorly financed, if financed at all, by funds specifically allocated for that purpose."[1]

Professor Philip M. Hauser, writing at a time when it seemed likely that basic social science research would be provided for by Congress under a National Science Founda-

[1] "The Status of Research in the Midwest Sociological Society," *The Mid-West Sociologist,* v. 12, No. 2, pp. 15-16 (Spring, 1950).

tion, asks the question, "Are the Social Sciences Ready?" and gives a qualified negative answer when he declares that "new research perspectives are badly needed—perspectives not restricted to projects forced into the molds of the spotty and limited financial support of the past." He goes on to express the hope that "adequate financial resources will increase the necessity for, and should increase greatly the number of studies made by competent groups rather than by individual investigators."[2]

Corporate research should not be confused with *joint research,* nor even with *cooperative research* in the usual sense of the latter term. Joint research in science is the equivalent of the *partnership* in business. It is the situation where two or more individual workers, usually representing the same discipline and often the same field of specialization, pool their efforts and results. The type of project undertaken by joint researchers is generally little different from the individual research project, and while the scope of investigation may be broadened considerably and the amount of data amassed may be more imposing, joint research nevertheless has most of the characteristics, and limitations, of individual research.

All scientific research is cooperative in the sense that every investigator makes use of and builds upon the work of others. In the narrower sense in which the term is ordinarily used, however, cooperative research denotes a certain loose cooperation between individuals or institutions (especially the latter) involving, among other things, exchange of information about projects being worked on, conferences on methodology, mutual exchanges of personnel, and in some cases a pooling of data. An example of cooperative research in which data are pooled would be a series of parallel surveys undertaken in different communities by different investigators, but employing a common schedule so that data collected will be more or less comparable. If joint research is comparable to the business partnership, cooperative research may be compared to the trade association in its looser forms. This is not to disparage cooperative research, or cooperation in research. There is need for much more cooperation than now exists in the social sciences and it is not contended that the development of corporate research would reduce the need for cooperation in research. *Social Science Abstracts,* which perished during the depression and which certainly should be revived, was a cooperative enterprise involving interdisciplinary and inter-institutional cooperation in reporting research.

Carrying to its logical conclusion the scheme of analogy we have used in comparing joint research to the business partnership, and cooperative research to the trade association, we may say that corporate research is just what its name implies—the application of the principles of corporate organization to scientific research. As implied in the definition at the beginning of this paper, it involves (1) division of labor, as distinguished from parallel effort, (2) maximum utilization of specialized training and talent, (3) interdisciplinary team work, (4) integration of effort under leadership, and (5) a research plan providing for continuity of effort and the focusing

[2] "Are the Social Sciences Ready?" *American Sociological Review,* V. 11, pp. 381, 382 (Aug. 1946).

of diverse viewpoints upon a single problem or problem complex. Though not implied in our original definition, and not essential to the basic concept, it is important to note also that corporate research, like the business corporation, may make possible a better utilization of available economic resources and also bring to the support of scientific research larger aggregates of capital than are likely to be made available to the less organized forms of research.

1. *Division of labor.* — Adam Smith, in *Wealth of Nations,* pointed out that in his time (c. 1776) it was not uncommon for an English "factory" to consist simply of a warehouse in which a number of skilled workers pursued parallel enterprises, each one performing all the successive operations involved in converting raw material to finished products, and that the output of such a factory was simply the sum of the individual outputs. But he went on to show that a transition was in progress, and that in one industry, the manufacture of the common pin, the manufacturing process had been broken down into separate and successive operations, with the use of teams of workmen in which each worker performed only a single operation; and he pointed out that, as a result of this division of labor, a team of workers was able to produce several times as much as the sum of the outputs of a similar number of workers working as individuals. In the twentieth century, the advantages of division of labor in industry are universally accepted, but scientific research with few exceptions has not yet reached even the stage of the warehouse "factory." It reposes in a still earlier stage—that of cottage industry and the individual craftsman!

In defense of this analogy, it is asserted that industry and scientific research have many essential things in common. Each calls for the exercise of a variety of highly developed skills, each involves well defined processes which can be broken down into concurrent and successive operations in which specialization leads to greater skill and efficiency, and each makes use of tools (or instruments) and stands to gain from that sort of organization in which the worker does not waste time in putting down one tool and groping for another. The universe of scientific knowledge, like that of technical skills, has expanded to the point where no one person can hope to master more than a small segment, yet nations and individuals are daily confronted with problems which call for the concerted, and integrated application of many fields of scientific knowledge.

Imagine, if you can, the plight of a person desiring a modern automobile who is obliged to procure all the necessary raw materials, then seek out workmen with all the necessary skills, then transport his materials from shop to shop until all the parts are finished, and finally assemble the parts himself. Yet such, precisely, is the plight of the man, or the nation, which seeks scientific guidance in the solution of any of the complex problems which we designate by the term "social."

2. *Maximum utilization of specialized training and talent,* as indicated above, is attained only in a situation where tasks are allotted according to special skill and ability and the whole process is so organized as to avoid duplication of effort, but at the same time insure that all needed operations are performed in proper sequence. Anyone who has

had even superficial contact with research in the social sciences must be aware of enormous duplication of effort. If not, a perusal of some of the annual lists of doctoral dissertations in the social sciences is recommended. Even at the level of advanced research, universities and individual scientists compete openly with each other in the exploration of certain favored fields, and turn a deaf ear to proposals for division of the field and the sharing of results, doubtless for the unspoken reason that to do so would involve sacrifice of institutional or individual credit and prestige, though the shibboleth of freedom of scientific investigation is likely to be advanced as public justification of their disinterest, if justification is demanded.

But duplication of effort is not the only loss we sustain because of our highly atomized and individualized research. Because choice of research problem is largely a matter of personal bent (or institutional bias), research tends to be spotty and discontinuous, so that when one surveys the field of social phenomena as a whole, he finds certain areas mapped and plotted in great detail—even trivial or useless detail. These are the popular areas, the areas of research toward which attention runs.

For example, in sociology, family relations, juvenile delinquency, social disorganization (a rather vague and formless concept), and recently, race or minority group relations have been strong favorites. But at the same time there are vast areas of *terra incognita*. Some of these areas, such as religious behavior and sex behavior, are fenced off by institutional bars. A certain amount of peripheral exploration is permitted, provided it is done delicately and reverently, but one must not go into the dark woods, and one must be careful not to step on the flowers or frighten the little rabbits.

On the other hand, there are large and important areas which are neglected for no discernable reason save that nobody seems to be interested in them. For example, sociology has largely neglected the study of popular music and other forms of popular art; and while sociologists have studied intensively certain aspects of criminology, the study of law-making, law-observance, and law-enforcement as social processes has been neglected. Social workers and sociologists have long been concerned with the effects of poorly balanced diets, but sociological literature contains only a few small and scattered studies dealing with the relationship of food habits to other aspects of culture such as intergroup prejudice and social status. Here is certainly a problem for interdisciplinary teamwork with dietitians, physiologists, psychologists, and sociologists all playing on the team.

It is not contended that corporate research will solve all problems of mal-distribution of research effort, but like the Scandinavian gentleman's daily ration of sixty-four cups of coffee, "it will help." It will help in four ways: (1) Corporate organization of research will certainly reduce the amount of needless duplication of research. This point seems so obvious that space will not be taken to argue it. (2) Confronting barriers of prejudice or tabu, an organized group with respected institutional backing can make a stronger attack, with less individual risk than can the lone researcher. (3) With respect to the neglected areas in the research map, it may reasonably be assumed that interdisciplinary team-

work will help. Bringing together investigators trained in different fields means that more questions will be asked and the searchlight of science will be played over a larger area. (4) A research team on which different but mutually supporting fields of specialization are represented will be able, not only to see more aspects of a central problem, but to pursue more related lines of inquiry and hence avoid the errors of particularism which have appeared so often in the social sciences.

3. *Interdisciplinary teamwork.*—In the preceding section we have already pointed out how interdisciplinary teamwork can contribute to the more effective utilization of specialized training and talent and lead to a broader concept of problems and more comprehensive investigations. Interdisciplinary teamwork appears to offer one answer to the dilemma of *specialization versus understanding,* i.e. a means whereby the social sciences can supply, not only the minutely detailed knowledge of the specialist, but also broad understandings which can come only from knowledge which is both intensive and extensive, and which are so necessary in the processes of prediction and planning.

For example, to understand and deal effectively with intergroup relations—racial, ethnic, religious, or economic—calls for a team in which anthropology, economics, psychology, and sociology are represented, because that complex social phenomenon which we call *prejudice* is far more than a pre-judgment or fallacious belief which can be speedily vanquished by giving people the facts. It is a witches' brew, compounded of folk myths and superstition, religious convictions, economic interests, sentiments of group loyalty, vague fears and anxieties, displaced hostilities, and frustrations, with added special ingredients according to the particular brand of prejudice. Nothing could be more futile and absurd than trying to deal with so complex a phenomenon as if it were a simple matter of interpersonal understanding which can be cleared up by getting the facts in the open and bringing the parties together so that they can shake hands.

4. *Integration of effort under leadership.*—Anyone who has ever had the experience of working on, or with, a faculty committee knows that even scientifically trained minds, without leadership, have a disconcerting tendency to "ride off furiously in all directions" and spend a precious afternoon in getting nowhere at all. Corporate research involves, as an essential element, the existence of acknowledged leadership and the willingness of all persons engaged in such research to respond to leadership. This does not mean mechanical control nor the sacrifice of what we ordinarily understand as intellectual freedom and integrity. In the staff conference ideas and proposals may be batted around the circle without regard to the rank or seniority of their authors, but in the end, if there is to be an end, someone must be able to fuse divergent proposals together into a plan acceptable to all. And when divergence becomes so sharp that this is not possible, there must be someone, commanding the respect of all, to make a decision. Admittedly this involves risk, and some compromising of freedom, but so does marriage, or signing a contract, or entering into any significant social relationship.

This seems particularly applicable to research carried on by graduate students in our universities. Working individually and guided only by occasional conferences with busy professors, they turn out each year scores of theses and dissertations containing vast accumulations of painfully collected data which the student has analyzed mechanically, by methods learned the previous semester. Problems selected are often inconsequential, or so narrowly defined as to be of little significance unless supported by related studies; and the interpretation of findings is halting, confused, and lacking of insight. Surely the minds and energies of these young people could be utilized better if they were assigned to work for a semester, or a year, with an organized group under skilled leadership, instead of being forced to strike out on their own.

5. *A research plan.*—Stressing the need for more and better planning in social science research, Professor Hauser insists that

> we must regard it as a basic obligation, to plan social science research projects that meet the requirements of good design of experiment. This does not mean that all research projects must be put into a test tube or brought into a laboratory, or that all research projects must be quantified. It does mean, however, that all important variables involved in a given problem should be brought under "control". It does mean that steps should be taken to assure that the population studied is a representative population—representative of the entire universe from which it is drawn or a selected segment of that universe which can be rigorously described. It does mean that the study should be set up in a manner to permit generalizations and conclusions whether they be of a positive or negative nature. Too many researchers in the past have, largely because of limited resources, stopped where they really should have begun—at the point where qualitative or quantitative studies have provided initial insights into the problem under exploration. Exploratory case studies or statistical studies will, of course, still be necessary, but adequate resources should result in projects which follow through—in carefully designed studies in which the variables are known and controlled and which result in statements of social laws and probabilities.[3]

The essence of a research plan is to be found in the concept of continuity—logical continuity and temporal continuity. Research should have logical continuity in the sense that it covers completely a defined area of investigation and maintains scientific liaison with related areas; it should have temporal continuity in the sense that it builds upon the validated results of earlier research and at the same time provides leads for future investigation and further validation. There are at least five requirements for a sound research plan.

To begin with, a research plan must be built around a defined problem, or problem complex. A problem may be defined in terms of a specified category of social phenomena, for example, competition or assimilation, in which case it is usually designated as a *theoretical* problem; or it may be defined in terms of a specified institution or institutional pattern, for example, marriage, education, or a specified group or population, in which case we designate it as a *practical* problem. As the social sciences have operated until now, the emphasis upon the practical type of problem has been much stronger than in the case of the theoretical, and there is probably little reason to suppose that this situation will change, nor to wish that it should change, for the soundest structure of theory is often that which is built up in the process of finding solutions to practical problems. The important thing is that the problem, whether "practical" or

[3] *Ibid.*, p. 382.

"theoretical," shall be so defined as to include all ramifications and permutations. In other words, the great sin of research planning is oversimplification of the problem.

A second requirement of good research planning is the collation of all existing research data which have a bearing on the problem, in order that unnecessary repetition may be avoided, and the investigation may be so ordered that it will add to present knowledge. The importance of this is obvious, but the means of doing it, so far as the social sciences are concerned, are not obvious. Because of the individualistic and unorganized character of social science research in the past, and in the absence of classified lists and cross-indexes of published research data, it is virtually impossible for a social scientist today to know what has been done, or even what currently is being done with respect to a certain problem.

Having defined the problem and taken account of all existing knowledge which bears upon it, the third step in research planning is to formulate a series of hypotheses which shall, as far as possible, cover all solutions to the problem which are logically conceivable in the light of existing knowledge, and this leads directly to the fourth step, which is the designing of an experiment (using that term in its broadest sense), or a related series of experiments, which shall test, not one, but all of the hypotheses. Good experimental design, as Hauser has indicated, means setting up a plan of inquiry in such a way that when the inquiry is completed, the various hypotheses will either be "proved" or "disproved." A conclusion which falls short of this is really no conclusion at all.

Finally, in the sound plan of research, there must be an analysis of the task and a determination of the personnel needs. What disciplines and what fields of specialization within disciplines need to be represented in this study? When this has been done, the plan may be said to be complete; there remains only the administrative (and perhaps financial) problem of finding suitable staff and organizing them into a research team.

For most institutions now engaged in social science research, corporate research must be regarded as a goal to be approached gradually rather than as a procedure to be adopted immediately. One obvious reason for this is the problem of financial support. Large-scale, comprehensive research projects of the sort described here call for research budgets seldom dreamed of in the social sciences. Moreover, they call for an entirely different sort of grant from that which foundations and research councils are accustomed to make. The practice which has developed and become strongly entrenched in the social sciences is for available research funds to be parcelled out in small grants ($500 to $3,000) to individuals on the basis of competitive "bids." If progress is to be made in the development of corporate research, institutions and foundations must be educated to the point where they recognize that the structure of knowledge cannot be economically built by the same principles which govern the erection of a new wing on the gymnasium.

Yet one of the reasons for the niggardly support now given to research in the social sciences undoubtedly is to be found in the present shortcomings of social science research. In other words, *if the social*

scientists could do better research, they could get more money, and if they had more money, they could do better research. How is this circle to be broken? As indicated above, it cannot be done all at once, but I think it can be done. The first steps must, obviously, be taken by the social sciences themselves. Specifically, the following measures are suggested:

1. Organization of interdepartmental discussion groups or faculty seminars to promote a broader approach to social problems and lay the foundations for interdisciplinary teamwork.
2. Establishment of social science research committees or councils charged with the function of developing broad, coordinated research programs. Such groups already exist in many universities, but their usual function is adminstration rather than planning — they consider the "bids" of individual researchers and parcel out research funds or research time on an individual basis, making sure that no department gets more than its share.
3. Progressive integration of individual research efforts, including the "forced" research of graduate students, into a broad plan that is focused upon a locally or nationally significant problem complex.

The possibilities of action along these lines can be illustrated by an account of what we are doing at Southern Illinois University. For a long time, southern Illinois has been regarded as a problem area, but we at the University have come to regard it as an area of unrealized opportunity. From the standpoint of research, it is a veritable sociological laboratory, since it is culturally an interstitial area where the distinctive culture traits of northern and southern regions meet, intermingle, and not infrequently "slug it out." We have not yet been able to accomplish the first two steps outlined above, but within the Department of Sociology we have developed a long-range research plan which is based upon the corporate concept of research, have secured limited financial support from the University for this plan, and have hopes of getting foundation support. With a small budget provided by the University, we are collecting and collating presently available information about the area. We have been reasonably successful in persuading graduate students to work on research problems which fit into our plan, and in building up the staff of the department we constantly keep in mind the requirements of a well-balanced research team, which we find is not necessarily incompatible with the equally important objective of developing an effective *teaching* team.

In conclusion, I turn to a problem which I am sure has been troubling many during this discussion—the problem of possible dangers in corporate research. Will it destroy intellectual freedom and lead to regimentation of investigation, followed by regimentation of thinking? In answer to this question, I wish to assert, first of all, that there are vital differences between *integration* and *regimentation.* Indeed, it may well be argued that the survival of free society depends upon our discovering practical means of achieving integration of effort without regimentation.

In the second place, it is far from my intent to advocate corporate re-

search to the exclusion of individual research. There should always be a place for the investigator of rare talents who can perform a brilliant piece of research by himself, as well as for the unorthodox theorist whose hypotheses may seem insane to organized research agencies.

In the third place, while I have emphasized the adaptability of corporate research to large-scale projects, I am not blind to the dangers of cartelized research. I can, for example, foresee the possibility that a National Research Foundation, financed by Federal appropriation, might lead to a dangerous degree of cartelization, and I think the exclusion of social sciences from the benefits of the pending legislation may some day be viewed as a fortunate thing. The social sciences need scores of well-organized research teams, based on the campuses of our leading colleges and universities, and financed from many sources—local contributions, state or municipal appropriations, foundation grants, and even Federal grants where they can be obtained without sacrifice of local control or self-sufficiency. And all this, I must insist, is compatible with the concept of corporate research.

ZOOLOGY

THE USE OF HORSE STRONGYLE LARVAE IN SCREENING COMPOUNDS FOR ANTHELMINTIC ACTIVITY

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Since the discovery of the sulfonamides, research in chemotherapy has gone on at an ever-increasing rate. One phase of this expansion has been an intensification of the search for new and better anthelmintics.

The pattern of this type of research is essentially that which was used during World War II in searching for new antimalarial and antifilarial drugs (cf. Wiselogle, 1946, and Conference on the Chemotherapy of Filariasis, 1948). Hundreds and even thousands of compounds, selected more or less at random, are tested for activity. When a promising compound is found, other related compounds are synthesized and studied.

Because so many compounds are studied in the initial screening test, a rapid, cheap technic is essential. The host which one wishes to treat is usually unsatisfactory because it is too large, too expensive to maintain, or not available in sufficient numbers. Hence workers have turned to *in vitro* tests or *in vivo* tests in small laboratory animals.

Neither of these types of test is completely satisfactory. Both miss compounds which would be effective against parasites of economic importance; both give promising results with compounds which are later found to be valueless against these parasites. Brackett and Bliznick (1949), for instance, using *Nippostrongylus muris* in the mouse (*Mus musculus*), screened over 1625 compounds for anthelmintic activity. Among the known nematocides which they tested, carbon tetrachloride was fairly active, but tetrachlorethylene, hexylresorcinol, and phenothiazine were not satisfactory. Santonin and beta-naphthol were practically worthless; gentian violet, thymol, and n-butyl chloride were completely ineffective. On the other hand, trichloracetamide and some of its relatives were highly effective. Unfortunately, this compound turned out to be ineffective against *Strongyloides ratti* in the rat (*Rattus norvegicus*), *Syphacia obvelata*, *Aspicularis tetraptera*, and the adults and larvae of *Trichinella spiralis* in the mouse (*Mus musculus*), and *Litosomoides carinii* in the cotton rat (*Sigmodon hispidus*).

In the last analysis, if one wants to find a compound which is effective against a particular parasite in a particular host, he must test it against that parasite in that host. No other procedure will give definitive results. The screening tests simply help in the hunt.

In vitro tests are usually faster and cheaper than *in vivo* ones. It is not necessary to have facilities for

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housing and handling many experimental animals, and the tests can be done conveniently on a table top. On the other hand, the results obtained in an *in vitro* test cannot necessarily be carried over without modification to the living animal. The drug-helminth reaction is a relatively simple, clear-cut one *in vitro,* but introduction of a host into the reaction brings in many modifying factors. A compound which is active *in vitro* may not be active *in vivo,* and *vice versa.* And an effective compound might turn out to be too toxic for the host to be used.

In vitro tests can be carried out either on the adult worm or on larvae. The advantage of using the adult is that it is the stage for which animals are treated. The metabolism of the larva often differs from that of the adult, so that a drug which kills larvae might not kill adults, and *vice versa.* Nevertheless, larvae are often so easy to obtain and to use that screening with them is justified. Otto and Maren (1948, 1949), for instance, discovered the new antifilarial compound, arsenamide, as a result of screening with *Dirofilaria immitis* larvae.

The screening test which I shall describe is a modification of the test developed by Parnell (1936). It uses the larvae of horse strongyles as test organisms. These nematodes belong to the family Strongylidae. Dikmans (1945) lists three species of large strongyles (genus *Strongylus*) and 36 species of small strongyles of 11 different genera as occurring in horses and other equids in North America. Practically all horses have multiple infestations. It does not seem to matter a great deal which species is used in the test.

The eggs of these nematodes are passed in the feces. First-stage larvae hatch in about a day, feed in the manure, and molt to long-tailed second-stage larvae in another day. These also feed in the manure. In a few days they molt again to become short-tailed third-stage larvae. The second-stage cuticle is not completely cast, but is retained as a protective sheath around the third-stage larvae. These larvae do not feed. They leave the manure, crawl onto the vegetation, and are eaten by horses when they graze.

This test was originally designed to be used in searching for compounds which would kill the larvae on pasture. However, it is also applicable to screening drugs to be used against the adults.

Strictly speaking, this is not an *in vitro* test, since it is carried out against larvae in their natural environment. However, since no host is involved, the test is generally grouped with the *in vitro* tests.

The chemical compound to be tested is mixed with talcum powder to give it body. One-half gram of this mixture is mixed thoroughly with 4.5 g. of fresh horse manure containing strongyle eggs. The manure-talc-chemical mixture is placed in a small cheesecloth bag, which is suspended in a closed, 2-oz. wide-mouth glass jar. The jar is set aside in a dark cupboard for a week. By this time the larvae have reached the third stage, and many of them have migrated out of the feces. They collect in the droplets of condensation water which appear on the sides of the jar, and can be recognized by examining the condensation water with a powerful hand-lens (I use a 15-X microscope ocular).

If no larvae can be found, the bag is placed in a Baermann apparatus (a funnel with a piece of rubber tubing closed by a pinch-clamp).

Enough warm water is poured into the funnel to half cover the bag. If larvae are present, they migrate into the water. After an hour or two some of the water is withdrawn through the rubber tubing at the bottom of the funnel, and examined for larvae with a low-power microscope or hand-lens.

The presence of living larvae indicates that the compound was ineffective. In the work cited above, both Parnell and I counted the larvae, but I now feel that this is not necessary in a screening test of this type.

In the preliminary screening test, each compound is set up in concentrations of 0.01, 0.005, 0.0025 and 0.001 M. If these give promising results, further studies are carried out. In my earlier work, I used standard percentages of compounds, but comparisons on an equimolar basis are preferable.

Untreated controls are essential, since in an occasional manure sample the larvae failed to develop.

One advantage of using talcum powder as a diluent instead of attempting to dissolve the compounds is that both soluble and insoluble compounds can be studied without changing the technic. In addition, a compound whose solubility is not known can be screened without taking time to determine if it is soluble.

Because of the nature of this technic, it is impossible to tell whether a compound acts on the eggs or on the first-, second-, or third-stage larvae. This does not affect the value of the test for screening purposes. For more precise information, the effect on each stage could be determined separately.

The selection of a manure donor is important. A strongyle egg count of at least 1000 eggs per gram of feces is desirable. Horses will sometimes be found in whose manure larvae do not develop well; such horses cannot be used as donors.

So far over 150 compounds have been screened against horse strongyle larvae. The results on 70 have already been reported (Levine, 1949), and those on the others will be reported later. A number of promising compounds have been found, including several iodine compounds.

Among known nematocides which were tested, 1% sodium fluoride, nicotine sulfate, and phenothiazine killed all larvae in the manure, while 1% hexylresorcinol killed 99.5% (compared with the number of larvae present in the controls). When present in a concentration of 0.1% in the manure, crystal violet killed 53% of the larvae; hexylresorcinol, 79%; phenothiazine, 82%; sodium fluoride, 84%; and nicotine sulfate killed them all. This last compound killed 99 to 100% of the larvae in four tests at a concentration of 0.01%.

Summary

A cheap, convenient technic is described for screening chemical compounds for possible anthelmintic value, using horse strongyle larvae as test organisms. The compound to be tested is mixed with horse manure containing strongyle eggs. The mixture is suspended in a cheesecloth bag in a glass jar. The jar is set aside in a cupboard for a week, and the jar and manure are then examined for larvae.

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A COMPARATIVE STUDY OF NORMAL AND PIEBALD HAMSTERS*

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A coat-color mutation in the golden hamster *(Cricetus auratus)* was recently described (Foote, 1949). Preliminary studies of this mutant strain, designated piebald because of the white coloring about the face and eyes, suggest that there are variations from normal associated with the coat-color change. Keeler (1947a, 1947b) has indicated that certain coat-color genes manifest themselves in all parts of the mammalian organism by producing modifications of morphology, physiological nature, and behavior. In this piebald strain of hamsters the first morphological difference observed, other than coat color, was that these animals appeared smaller and their body weights were less than those of normal animals. A preliminary study of this weight difference has been reported (Foote and Bullock, 1949).

This report brings together some of the data accumulated during the past two years in comparing the piebald strain of hamsters with normals. Studies described here are for body weights, litter size and mortality, and reproductive tract abnormalities. Coat color for the mutant strain will be described and sex distribution discussed.

Results

Coat color.—The animals of the hamster colony used in this study were graded on the basis of coat color. The normal coat coloring for this species of hamster is light brown on the back and white on the underside, with a brown band across the chest between the forelegs. White areas extend from the fronts of the forelegs and from the throat region up and forward across the cheek pouches (fig. 2). An animal with coat color of this kind was graded as P-0.

The first noticeable variation from normal toward piebaldness is the appearance of a strip of white in the center of and at right angles to the brown band between the forelegs. This area of white becomes wider as animals tend more toward the piebald condition until the brown area is entirely absent. Animals showing variations in the degree of white on the chest were graded P-1 to P-5 (fig. 2). The animals graded P-5 have no brown color on the underside and are completely white on belly, chest, and throat. Animals in grades P-1 to P-5 show the normal brown color on the back.

Animals graded P-6 to P-10 show varying degrees of white on the nose, face, and back, and lack all brown color on the underside (fig. 3). Young animals will show the piebald color pattern as soon as they become pigmented after birth, on about the third day, and the pattern is never varied as the animal becomes older.

In the present paper the hamsters in grades P-0 to P-2 (344 ani-

* Aided by grants from the General Research Fund, Southern Illinois University.
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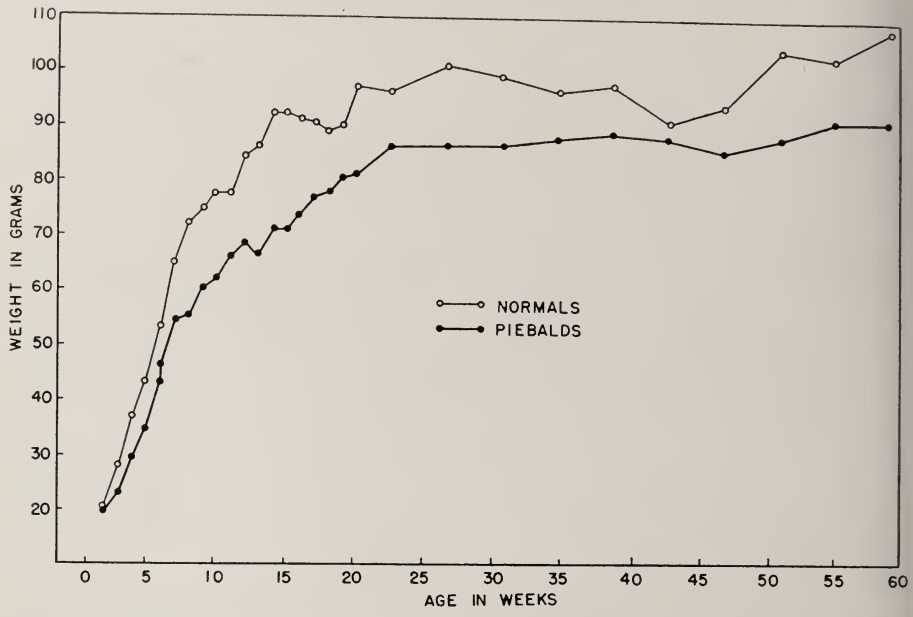

FIG. 1.—Comparison of mean body weights of normal and piebald hamsters. Points up to 23 weeks plotted by weeks; points after 23 weeks plotted by months.

TABLE 1.—SEX DISTRIBUTION

	P-0	P-1	P-2	P-3	P-4	P-5	P-6	P-7	P-8	P-9	P-10	
Females	72	62	36	9	16	9	6	7	9	4	8	238
Males	71	81	22	10	12	7	12	5	8	1	10	239
Total	143	143	58	19	28	16	18	12	17	5	18	477

mals) are considered to be normals, while those in grades P-3 to P-10 (133 animals) are considered piebalds.

Sex distribution.—In the total colony of 477 animals the sexes were almost equally divided, 238 females and 239 males. Distribution by sex and grade is given in table 1.

Body weight.—The first observed variation from normal in the piebald animals, other than coat color, was in body weight. It appeared that they were somewhat smaller and weighed less than normals.

Body weights were taken weekly for a period of 58 weeks on a Hanson Dietetic Scale, on Friday afternoon of each week, before the animals had been fed for that day. All animals were fed the same diet of leaf lettuce, laboratory chow, and milk. Weights of most animals were taken from the time they were 16 days old, the time of weaning. The total number of animals weighed each week varied somewhat since they were being used in other studies and some had to be sacrificed.

Normal animals showed a consis-

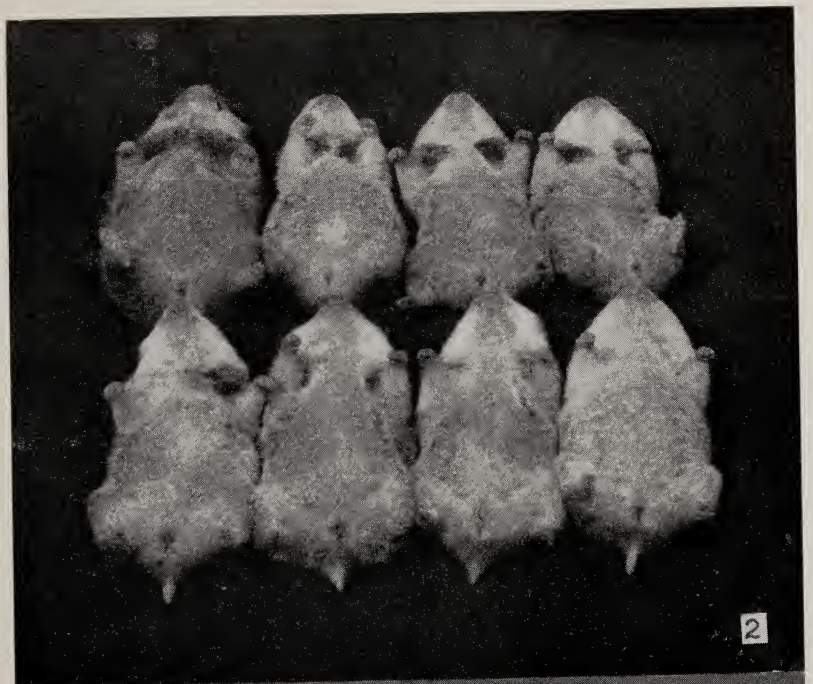

FIG. 2.—Undersides of normal and piebald female hamsters showing varying grades of piebaldness. Female on upper left is P-0; female on lower right is P-10.

FIG. 3.—Backs of same animals as in fig. 2. All are in same relative positions in both photographs.

TABLE 2.—BODY WEIGHTS
Mean weights in grams

Age in Weeks	Normal males		Piebald males		Normal females		Piebald females	
	No. Wts.	Mean Wt.	No. Wts.	Mean Wt.	No. Wts.	Mean Wt.	No. Wts.	Mean Wt.
2.....	27	20.48	13	20.69	13	17.77	12	17.50
3.....	27	27.59	28	22.82	17	25.59	21	20.05
4.....	38	37.74	37	28.27	45	35.38	28	27.71
5.....	46	45.39	46	35.28	47	39.02	30	33.33
6.....	31	52.77	49	44.72	35	52.43	27	44.93
7.....	26	64.39	52	53.60	36	64.00	29	53.69
8.....	36	71.50	45	56.01	44	70.95	32	53.84
9.....	33	72.36	53	59.84	27	73.30	40	58.30
10.....	30	76.43	50	62.72	17	76.65	26	61.00
11.....	22	78.90	36	63.88	13	80.07	20	66.50
12.....	20	81.50	28	66.07	13	87.07	17	68.82
13.....	13	80.92	19	65.31	10	90.10	16	65.81
14.....	11	85.54	9	70.44	8	99.00	10	72.81
15.....	14	86.21	16	68.00	9	98.33	13	72.84
16.....	10	80.50	15	73.06	8	99.62	10	71.80
17.....	4	86.75	11	78.81	3	92.33	8	73.12
18.....	12	81.25	15	74.60	8	96.25	10	74.70
19.....	4	87.50	14	77.23	2	90.50	6	84.66
20.....	7	91.57	13	79.46	3	97.00	6	82.50
21-60.....	114	98.05	235	84.70	50	92.45	118	89.38

tently heavier body weight than did piebald animals (fig. 1), as indicated by mean weekly weights of total number of normal animals compared to mean weekly weights of total number of piebald animals. The difference in the mean weights of the two groups for the period of 58 weeks was 12.13 grams. The greater body weight of normals becomes apparent when the animals are about 3 weeks old and the difference in weight between normals and piebalds gradually increases until they reach the age of 14 to 15 weeks. Apparently it is at the approximate age of 15 weeks that the hamster begins to reach its adult weight, since from that time on no great increase in weight is evident.

The weight difference between piebalds and normals remains more or less constant after the animals reach their adult weights. While the weight attained at 20 weeks remains somewhat stable, the piebald and normal females show little weight difference as adults. The weight difference between normals and piebalds is accounted for by the weights of the males of the two groups (table 2). Of the 4 groups of hamsters, normal males, normal females, piebald males, and piebald females, the normal males are heaviest while piebald males weigh the least.

Litter sizes and litter mortality.—In the hamster fewer young are born to piebald mothers than to normal mothers. When litters are produced from matings of normal males with normal females the litters are larger (mean litter size of 6.69), and more of the young survive (4.81). If either or both parents are piebald there are fewer young in a litter (4.76), and the mortality of the young is higher (2.72 surviving). Litter size and mortality are given in table 3.

TABLE 3.—LITTER SIZE AND LITTER MORTALITY

	No. of Litters	Total Young Born	Young per Litter Born	Young per Litter Surviving	Total Young Surviving	Percent Young Surviving
Normal male X Normal female	62	415	6.69	4.81	300	72.29
Normal male X Piebald female	8	50	6.25	3.50	50	56.00
Normal female X Piebald male	35	191	5.46	3.63	127	66.49
Piebald male X Piebald female	50	202	4.04	1.96	98	48.52
Normal female X Piebald male Normal male X Piebald female Piebald female X Piebald male	93	443	4.76	2.72	253	57.12
Normal male X Piebald female Normal female X Piebald male	43	241	5.60	3.14	135	56.01
Entire Colony	155	858	5.54	3.57	553	64.44

The young from piebald parents are smaller and weaker than normal young and as a result the mother animals, whether normal or piebald, are prone to destroy them. In addition to this factor, piebald mothers are more nervous and do not care for their young as well as normal mothers. The young of piebald mothers are more likely to starve and die from neglect.

Reproductive tract abnormalities.—In piebald animals a condition of either partial or total sterility may exist, especially in females. No detailed study has been made of the cause of sterility in the male piebald animals, but in the case of one male, graded P-10, who was mated numerous times to both piebald and normal females, no young were born. Cases of non-fertile matings are more common among piebald animals than in normals. Such non-fertile matings may be due to a condition of sterility in the male, the female, or both.

In a group of 42 piebald females that were sacrificed the reproductive tracts of 7 were abnormal. Among normal females, one with an abnormal reproductive tract was found in a total of 165 females sacrificed. The abnormalities observed were in the horns of the uteri. Of the 7 piebald females with abnormal tracts, 4 had no left uterine horn, one had a right uterine horn missing, and one had no uterine horns. In one instance the right horn was absent, but the left horn had been pulled across the body cavity and attached near the right ovary. Two of the 7 females had no left kidneys. In the normal female the left uterine horn was absent. In all of these cases the ovaries, fallopian tubes, and lower portions of the reproductive tracts appeared intact.

All females with reproductive

tract abnormalities had at some time been in estrus, exhibited the usual sexual behavior, and had copulated. Each had mated at least twice and some as many as 6 times. In only one case were young known to have been born and that female had a record of four matings, three of which had been non-fertile. After the fourth mating she gave birth to a single animal. After the mother animal had been sacrificed it was found that she had only one uterine horn, the right.

The investigation of these reproductive tract abnormalities is incomplete and more detailed study is in progress.

Discussion

Coat-color changes in hamsters (*Cricetus auratus*) similar to the one described in this paper have occurred in other hamster colonies in this country. Dr. Margaret Ward Orsini, in a recent personal communication, stated that piebald animals which appeared in her colony and were then inbred for several generations, developed a greater degree of whiteness than have these animals in the colony here. Hayner (1949) reported a white-faced hamster mutant appearing among the animals in his hamstery. As far as is known no studies of the genetics of this piebald mutation in the hamster have appeared in the literature.

Data presented in this paper suggest that there are certain morphological variations and possible differences in maternal behavior between piebald and normal hamsters which may be related to the coat-color modification of the piebald animals. Keeler (1947a) has advanced the hypothesis that such differences, in many mammalian forms, are due to a relationship between a mutant coat-color gene and its correlated modifications of morphology, physiology, and behavior. Even though results obtained from these studies of the piebald mutant suggest that there is such a relationship, no definite statement should be made until the genetics of this strain of hamsters is more fully understood and other studies completed.

Results presented here for the normal hamster vary little from those reported by Bond (1945). Body weights of normal animals in this colony show a slightly higher mean body weight up to the time the animals are 100 days of age. After that age the weights are approximately the same as those given by Bond, with normal males being heavier than normal females.

Bond found that the mean litter size in her colony was 6.93, as compared to a mean litter size of 6.69 reported here.

Summary

1. Normal hamsters (grades P-0 to P-2) show a greater body weight than do piebald hamsters (grades P-3 to P-10).

2. The sex ratio is 1:1 among normal and piebald animals.

3. Normal hamsters have larger litters than do piebald hamsters, and more young survive in litters produced by normal animals.

4. Reproductive tract abnormalities occur more frequently in piebald females.

5. The differences in morphology and behavior of piebald hamsters may have a relationship to the mutant gene or genes producing the coat-color change.

6. Those animals considered

normals in this study have body weights and young per litter similar to those given for a different hamster colony.

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PROBLEMS IN THE BIONOMICS OF THE SQUASH BUG, *ANASA TRISTIS* (DeGEER) (COREIDAE, HEMIPTERA)

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Although numerous articles have been published on the squash bug, the bulk of the material concerns methods of control, and many questions in the area of its bionomics have either remained untouched or received insufficient consideration. The squash bug has several characteristics that favor it for observation and experimentation: (1) it is large —about ⅝ inch in length; (2) it is common; (3) the sexes are readily distinguished; (4) all the stages are passed in full view above ground and can be reared in captivity; and (5) while capable of flight, the adults tend to remain on foot if food is adequate and the temperature moderate. In view of its suitability for research, a brief summary of its essential bionomics is desirable.

The squash bug appears to confine its feeding to members of the family Cucurbitaceae, favoring certain varieties of squash and pumpkin. The coppery brown eggs are attached in loose groups to the underside of leaves, and the five instars of greyish nymphs and the brown adults appear on foliage and vines during the growing season. When frost kills the leaves, both nymphs and adults may accumulate, sometimes in large numbers, on the cucurbit fruits left in garden or field after harvest. The nymphs, while small, tend to remain congregated about the site of the eggs, but they become isolated as they grow larger. Only the unmated adults live through the winter, sheltered under rubbish, boards, stone piles, and similar cover. In the northern states, the wintered adults return to cucurbits in June, mate and deposit eggs largely in June and July. The nymphs grow through their five stages from midsummer to October, the old adults die by the late summer and the number of new adults increases from July to October. In this latitude and northward, there appears to be only one generation a year. The eggs are subject to attack by minute endoparasitic Hymenoptera of the families Scelionidae and Encyrtidae while the larva of a tachinid fly, *Trichopoda pennipes* Fabr., inhabits and destroys both the adults and nymphs (Beard).

Notes on Problems

Sex ratio.—While observing the behavior of confined squash bugs, Girault found that males mated repeatedly and with different females. From this polygamy, he inferred that the males are numerically inferior to the females. However, this inference is shown by the data cited below to be incorrect. In his study in Connecticut, Beard collected 1000 adults in August and September, 1935, which "showed 449 males and 501 females, indicating that the newly matured bugs have a sex ratio of .5. . . . Tabulations made during June and July, 1936, of 1430 overwintered bugs, gathered at random

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TABLE 1.—LENGTHS AND SEX RATIOS OF *Anasa tristis*

Date of Collection	Length in Millimeters						Total Bugs Collected	Males		Females	
	Males			Females							
	Number Measured	Extreme Lengths	Average Lengths	Number Measured	Extreme Lengths	Average Lengths		Number Collected	Percent	Number Collected	Percent
October 6.....	74	12.4 15.2	13.65	76	13.0 16.6	15.36	992	494	49.80	498	50.20
October 8.....	77	12.0 14.8	13.36	78	13.7 16.5	15.00	995	561	56.38	434	43.62
October 9.....	50	12.3 14.5	13.22	49	13.3 16.3	14.80	781	383	49.04	398	50.96
October 10.....	118	11.6 14.7	13.34	114	13.3 16.5	14.83	2,007	1,061	52.86	946	47.14
October 13.....	99	11.5 15.0	13.05	100	13.1 15.3	14.46	1,284	658	51.25	626	48.75
October 15.....	32	12.0 13.4	12.71	34	13.2 16.0	14.47	66	32	48.48	34	51.52
October 21.....	73	11.2 13.6	12.54	87	12.5 15.3	13.94	164	73	44.51	91	55.49
October 28.....	18	10.8 13.0	12.23	25	12.6 15.7	13.93	43	18	41.86	25	58.14
November 6....	3	12.8 13.0	12.93	4	13.5 14.7	14.07	7	3	42.86	4	57.14
Totals.....	544			567			6,339	3,283	51.79	3,056	48.21

in the field, included 653 males and 677 females, the difference being of no significance as tested by the Chi-square.''

In the fall of 1942, I discovered a fine population of nymphs and adults in a one-eighth acre of squash and pumpkin at Urbana, and used it to secure data on the relative numbers of the sexes. Nine separate collections were made, at times stated in the accompanying table, in the period October 6 to November 6. The numbers taken per day do not represent the total bugs then present, but reflect merely the intensity and duration of the periodic searches. However, all but a very few of the individuals that constituted the population were, I believe, secured by November 6. And because the bugs showed no inclination to fly when pursued, no significant part of the population was omitted through emigration, nor the number present supplemented significantly, if at all, by immigration from other areas. Only the obviously more mature dark-brown adults were taken on any date, to avoid prejudicing the measuring of lengths by the inclusion of smaller, newly molted unfed individuals.

The daily lots were assembled alive in a ventilated half-gallon fruit jar, the cover having a hole just large enough to receive a bug inserted lengthwise, in order to prevent escape. After asphyxiation in ether, the individuals were segregated as to sex and a sample of each sex measured. The ventro-caudal area of the male abdomen is transversely convex and entire, excepting a small median genital ''button,'' while that of the female tends to be flat and is subdivided into small genital sclerites.

Reference to the table will reveal that 51.79 percent of the 6339 bugs that made up the collections were males and 48.21 percent were females. It seems likely that each sex would be found to constitute 50 percent of the population or species if much larger samples were taken over a succession of years and from a number of separate fields. The variations in the percentages of males and females taken on the 9 dates are probably to be attributed to chance, and do not indicate an actual or normal fluctuation in numerical preponderance of one sex over the other. Moreover, Beard found no evidence to indicate a differential mortality that alters the 50-50 ratio of the sexes throughout the year.

The females of this sample exceeded the males in length of body by 1.39 mm. The 567 females measured averaged 14.53 mm., the 544 males averaged 13.14 mm. in length. The largest female measured 16.6 mm., the smallest 12.5, while the largest male had a length of 15.2 mm., the smallest 10.8 mm. Moreover, the size of both males and females lessened perceptibly and somewhat gradually as the period of collecting progressed. Since nymphs were always purposely left in the field in order to permit them to become adults, it is probable that the later collections contained a high proportion of newly transformed adults. And because late-maturing individuals were obliged to feed on the old fruits, the leaves and vines having been killed by frost early in October, the phenomenon of diminishing size appears to reflect an inadequacy of food. Also the progressive shortening of the days and lowering of temperatures as October progressed may have contributed to this reduction.

The life cycle. — Gould, Beard,

Worthley, and Weed and Conradi report one generation in a year in Indiana, Connecticut, Massachusetts, and New Hampshire, respectively. By inference, some writers suppose the squash bug completes one cycle annually also in other northern states, but this point needs to be checked by studies in the field. Moreover, this bug has two generations per year in Missouri (Haseman) and three in southern Kansas (Wadley), and may produce even more cycles still farther south. Such additional cycles, are, it appears, commonly presumed to result from the higher average temperatures prevailing at more southerly latitudes. However, these supernumerary cycles may be even more directly associated with the long occurrence of succulent growing cucurbit tissues that is made possible by the protracted warm period.

Diapause.—New adult squash bugs develop as early as July in the northern states. Although they exist at temperatures favorable to reproduction from July to September, they are known not to mate and produce eggs until the subsequent summer. Such failure to advance the life cycle at summer temperatures is a characteristic of diapause. The problem here concerns the identity of the presumed non-climatic factor that inhibits sexual activity in July-September, and limits the squash bug to one generation in the north. Some studies on diapausing insects point to the low water content of drying or aging plants as the diapause-producing factor. It is said to lower the water content in the insect. This suggests that nymphs and adults fed only on succulent seedling cucurbits may not be subject to a diapause. Simple laboratory tests embodying this suggestion can probably be easily carried out.

How cucurbits are injured.—Being equipped with piercing-sucking mouthparts, *Anasa tristis* removes sap from its food plants. However, such mechanical removal of sap, in itself, seems inadequate to explain the sometimes extensive wilting, searing, and dying of cucurbit crops. Various writers have called attention to this wilting, and Robinson and Richards (1930, 1931) state from their investigations that the wilt, for which they propose the name "*Anasa* wilt of cucurbits," is not caused by any parasitic form of bacterium, fungus, or virus. These and other observers suggest that the wilting results from a toxic substance injected by the bug while feeding. If so, the toxin is probably contained in the saliva, or salivary glands, and quantities of it might be analyzed by modern microchemical techniques and also injected artificially into potted, disease-free cucurbits to note whether it produces the symptoms of wilt as it occurs in the field. If the results prove to be positive, the substance might be injected into non-cucurbit plants to note whether it has the power to produce wilt in these also.

Why the preference for cucurbits?—The fact that the squash bug chooses cucurbits over numerous other plants present in its environment, and moreover, prefers certain varieties of squash and pumpkin over other species and varieties of the family, indicates it is capable of making fine distinctions, presumably through a keen sense of smell residing in the antennae or proboscis. This predilection also raises the question whether cucurbits contain a certain combination of nutrients

essential to the growth and reproduction of the squash bug. Two experiments are indicated above. First, to find what organ is the seat of selective sense. Second, to find whether the squash bug can be induced to feed on non-cucurbit plants, e.g. soybeans or corn grown in pots, when such plants are sprayed with extracts or decoctions from favored varieties of squash and pumpkin. If nymphs can be reared and adults maintained on such plants, it would be of interest further to note the effects on size, vigor, rate of growth, and capacity for reproduction. It is conceivable that the species might fare better on some non-cucurbits than on the preferred varieties of its chosen family of food plants.

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ECOLOGICAL NOTES ON *THANATOPHILUS AMERICANA* L.

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Thanatophilus americana L. is a carrion beetle of the family *Silphidae*, tribe *Silphini*, and subgenus *Oiceoptoma* Leach. This species is broadly oval and, like the rest of its tribe, strongly depressed. It is about five-eighths of an inch long. The prothorax is yellow with a central black area, and the rest of the body is black or brownish black. Blackburn (1936) describes the morphology of this beetle in detail, including the sexual dimorphism of the apices of the elytra. The campodeiform larvae are entirely black, very active, have an amazing capacity for food, are cannibalistic when food is scarce. The larvae of *T. americana* and related species have been described by Dorsey (1940).

T. americana has some advantages as the subject of field and laboratory studies. First, it is abundant in season and can be easily collected in baited traps. Second, the adults brought in from the field will live for long periods of time under suitable laboratory conditions. Third, the adults will lay eggs in the laboratory, the eggs can be hatched, and the young raised to the imago stage. Finally, Purina Lab Chow can be substituted for decaying meat as a diet for the beetle, thus eliminating offensive odors. The disadvantages are chiefly these: *T. americana* cannot be collected, at least in large numbers, except by rather smelly traps; it is available only during the warmer months; it is a large beetle and thus experiments with large numbers require much space.

In spite of these disadvantages, however, *T. americana* seems to be well adapted to certain types of laboratory work. This paper is intended to introduce *T. americana* to scientific society as a laboratory animal of sorts. Although the collecting of this beetle still involves malodorous bait, the odor is mitigated by fresh, outdoor air. And since the objectionable odors of decaying flesh have been eliminated from the process of maintaining this beetle in the laboratory, *T. americana's* debut may be moderately successful.

Collecting Methods

Cans sunken into the ground and baited with meat have probably been used from time immemorial for traps. But open cans are subject to the depredations of local carnivores, bait lying loose in the can quickly becomes messy, and rainwater may drown the trapped beetles. Certain precautions will avoid these mishaps. Cans with tight-fitting covers should be selected, preferably gallon paint cans, since the covers can be pried off easily after the cans have been sunk into the ground. A cross-shaped slit should be cut into the lid and the free ends of the triangles thus formed bent slightly inward. The jagged edges thus formed effectively prevent any purloining of the bait but do not interfere with the entry of the beetles. The bait should

be wrapped in gauze, tied with a string, and suspended from a heavy wire bar fastened across the diameter of the can near the top. If the bait is suspended with a bent paper clip, it can be taken out of the trap easily while the catch is being removed. Finally, the can should be located so that rainwater will not drain into it and a sizable hole left under it into which water can drain from holes punched through the bottom of the can. When these precautions are observed, ground traps prove to be very successful. The disadvantages are chiefly the immobility of the traps and the inconvenience of removing the beetles with the hand or long forceps.

More elaborate hanging traps can be constructed which eliminate the necessity of digging holes in the ground, and which can easily be moved from place to place. This provides for easy renewal of the bait, and the beetles can be removed merely by screwing off a glass jar and dumping them into a container. A plan for such a trap has been published by the Chicago Museum of Natural History. A modification of this trap was constructed by a local sheet metal shop in Quincy. Widemouth, self-sealing fruit jars were used. The center of the cap is discarded, leaving a metal ring which will screw onto either a quart or pint jar. The metal rims were soldered to a galvanized metal funnel. Three baffles were soldered to the funnel and screwed to a conical metal roof. A wire cloth capsule for the bait can be inserted easily into the central area of the baffles. This trap has been quite successful. A study of the relative efficiency of the ground and hanging traps and the effect of height will be undertaken during the coming summer.

Decaying fish has been used very successfully in the past as a bait in both ground and hanging traps, but there is a tendency for the bait to dry instead of putrifying in the hanging traps. Plans for testing chemical attractants are being made, since a constant lure would be invaluable in field studies. Dethier (1947) mentions some attractants for the *Nicrophorini* but none for the *Silphini,* except those generally attracting this type of insect.

Habitat

In the Quincy area, *T. americana* has been trapped in sparsely wooded, humid bottomland and along upland streams in wooded areas which remain moist during the summer. In this area, however, it is impossible to study habitats of flying insects accurately by trapping, since open fields, scantily wooded areas, and dense woods are interspersed and no type of habitat is very extensive.

During July 1947, eighteen days of trapping in the Chicago area yielded interesting results. Traps were placed in a parkland area near a stagnant pond, in oak forest, and in prairie. In the dunes area several traps were scattered through the black oak, cottonwoods, and foredunes. Each of these areas was very extensive, covering many square miles. Thus the catch gives some indication of the species present. The parkland traps yielded 460 *T. americana*, the prairie traps only one pair, and the traps in the oak forest one single specimen. *T. americana* was not found in the dunes area. These collections seem to indicate that *T. americana* is a parkland species, inhabiting open woods or semi-denuded areas where

water is available. It is absent from other environments, at least during the summer. At Quincy it has been collected from similar areas.

T. laponica was the only species present on the prairie in numbers and thus seems to be a prairie species, having been collected from no other area. It has not been taken in the Quincy area, a fact in favor of its being a native of the prairie. *T. inaequalis* was abundant in the forest of oak on upland areas and showed up in the black oak forest in the dunes area. *T. noveboracensis* was not notably abundant anywhere, but 27 specimens were taken in forest traps. Observations indicate that this species breeds early in spring. Recently, April 15, 1950, breeding individuals were observed on a carcass in upland woods, and shortly afterwards hundreds of larvae appeared. In the spring of 1947 traps were visited almost daily from April 8 to May 29. *T. americana* appeared later than the other species and was not taken at all or only in small numbers when the night temperature fell below about 50°F. Seasonal studies might show an interesting avoidance of competition between these species in terms of habitats and breeding seasons.

Husbandry

Laboratory observations and experiments have indicated the needs of *T. americana* for survival under domestication. Adult beetles will live for long periods of time in any type of container if provided with food and water. The bottom of the container should be covered with absorbent paper or soil. Water may be furnished in small glass dishes. Pieces of gauze or paper should be placed in the dishes so that the beetles can escape drowning by climbing out after falling or crawling into the dishes. Meat (cooked or raw), fish, and Purina Lab Chow have been used successfully for food. For life history studies, paired adults may be kept in wide-mouth fruit jars and covered with the original caps in which screen has been substituted for the removable center. Moist soil, water, and food must be provided. The lack of any of these items will stop egg production. The eggs are deposited in the moist soil in cavities excavated as the beetles burrow through the soil. The necessity of using moist soil usually excludes sifting for the eggs since most available soils do not sift well when moist. The eggs can be recovered by searching through the soil with brush and section lifter.

The eggs are large and cream-colored and enclosed in a pliable but tough outer cover. They will hatch successfully if placed in petri dishes on moist pieces of paper towel. The eggs quickly swell to about twice the size of a newly laid egg. If they are not kept moist they quickly dry and shrivel up. In this connection it is interesting to note that the adult beetles will not oviposit in dry soil, as shown by an experiment involving about four dozen pairs of *T. americana*. All of 409 eggs, laid over a period of two weeks, were laid in moist soil, although dry soil was equally available and convenient.

The larvae can also be maintained in petri dishes, but a wad of wet gauze to supply water and food must be added. During the third instar the larvae eat for the first few days and then become extremely restless unless placed in a container of moist soil where they hollow out a cell within which they pupate. The soil must be kept moist in order to insure suc-

cessful pupation and ecdysis. This latter point has the support of experimental evidence. Of a total of 56 third instar larvae which were ready to construct their earthen cell, 27 were placed in moist containers and 29 in dry containers. Of the 27 in moist containers, 24 pupated, 21 reached the adult stage. Of the 29 individuals placed in dry containers, 6 pupated and 2 reached the adult stage. Thus 77.8% pupated successfully in moist containers and only 6.9% in dry containers.

Life Cycle

The eggs hatch in from one to four days, the mean time necessary being about three and a half days. The time spent in the first instar varies from less than one day to about three and a half days. The mean time is slightly less than two days. The second instar is very similar in length to the first. The third instar is the longest stage in the development of this beetle. It varies in length from about 8 days to 14 days, the mean being about 11 days. The third instar larvae are very active for a few days, feeding and then constructing their earthen cell. A few days after the cell is complete, they turn over on their backs and become immobile, except for twitching the abdomen. The pupal stage varies in length from 8 to 13 days, the mean time required being about 8 days. The pupae are extremely sensitive to light and mechanical stimulation of any kind. Towards the end of the pupal stage they are less sensitive but still react easily to slight jarring and strong light. Hence it is difficult to examine them closely while alive. The pupae are almost pure white at first but soon develop a light brown coloration on spines, appendages, and peripheral areas. The adult beetles are very light in color at first. The elytra are a semi-transparent white whereas the body is a light brown. Full coloration is developed after two or three days. The mean length of time from egg to adult is about 26 days and varies from 25 to 27. These studies of the life cycle were carried out at a constant temperature of 25°C. They will be described in greater detail in another paper.

Discussion

The study of the complete ecology of *T. americana* and its relatives promises to reveal interesting interspecific adjustments. *T. americana* and probably also other species can be used in the laboratory for the study of the effect of temperature and food on the rate of development. Since this beetle will eat and do well on an artificial diet its nutritional requirements can be studied in detail. The adults are not overly sensitive to handling and thus make good subjects for behavior studies. Exploratory work along this latter line has been done. It must be said, however, that the usefulness of *T. americana* as a laboratory animal is still to be proved.

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THE OCCURRENCE OF *ENTEROBIUS VERMICULARIS* OVA IN DUST FROM HOMES AND PUBLIC BUILDINGS

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In recent studies, a theory has been proposed concerning the occurrence of ova of the pinworm *Enterobius vermicularis* in household dust. Lentze (1935) showed that eggs were liberated into the air when sheets and clothing contaminated with them were shaken, and suggested that the ova might be inhaled to produce infection. In studies by Noland and Reardon (1939) (see table 1) and Schuffner and Swellengrebel (1944), ova were found in dust at all levels of rooms examined, on the floor, upholstery, light fixtures, and on the moulding of doors and windows. The conclusion drawn from their experiments was that viable ova may be present in the air throughout an infected household and that the possibility of reinfection by inhalation of the ova must be considered in prophylaxis and in the therapy of individuals in such households. Our investigation was made to check further this possibility and to ascertain the occurrence of *Enterobius vermicularis* ova in the dust of institutions and homes in the Bloomington-Normal, Illinois, area.

In the study by Noland and Reardon (1939) of the incidence of *Enterobius vermicularis* in persons residing in or near Washington, D. C., the method of procedure consisted of collecting dust samples from various parts of the houses studied and subsequent microscopic examination. Pinworm ova were demonstrated in 221 of 241 samples studied (91.7 percent). Schuffner and Swellengrebel (1944) found enormous quantities of pinworm eggs on two-meter high window seats of school lavatories, in schoolrooms and in dining rooms where children stayed only for short periods.

In the work here reported 3 households and 24 public buildings were examined (see table 2). The 3 homes consisted of families with children. Two of them were not clean according to cleanliness standards. In the third home, the entire family was being treated for pinworm infection. Twenty-two samples of dust were obtained from these homes. Of the three samples of dust from the home where infection was known to be present, two positive findings were obtained. The 19 samples from the other two homes were all negative. A 9.09 percent positive finding resulted from examination of the 22 dust samples from the three homes.

The public institutions examined included: 8 schools, 2 orphanages, a children's ward in a hospital, 3 theaters, 4 hotels, 2 cafes, and 4 other public buildings. A total of 149 samples of dust were obtained from these buildings. Of these, 101 were from the orphanages. Only samples taken from the dormitories and restrooms of the orphanages gave positive results. An 8.1 percent positive finding for public institutions and a 11.8 percent positive

Table 1.—Comparison of Incidence of *Enterobius vermicularis* Ova in Household Dust of Washington, D. C., and Bloomington-Normal, Illinois, Area.

	Washington, D. C. (Nolan & Reardon)	Bloomington-Normal Illinois Area
No. of Homes	7	3
Households of Known Infection	7	1
No. of Samples	241	22
No. of Positives	221	2
Percent of Positives	91%	9.09%

finding for Bloomington-Normal orphanages was obtained.

Most samples from the three homes and the two orphanages were taken from bedrooms or dormitories. A few were taken from the toilet rooms. Samples were taken from all levels of the rooms, especially the framework of beds and places where linen and bed clothing were shaken out, and where night clothing and undergarments were located. In the toilet rooms, dust samples were taken from seats, ledges around the toilet, and the floor. It seems significant that ova were found in only one instance near the floor. They were usually found at levels of from two to five feet from the floor.

Two methods of dust sampling and study were employed: (a) the deep-well slide method as described by Noland and Reardon, and (b) the scotch-tape method as used by Schuffner and Swellengrebel for anal smears. The deep-well method consisted of the collection of dust samples with a small camel's hair brush which had been inserted into a perforated rubber stopper and fitted into a test tube. The brush was moistened with water, passed over a surface, replaced in the test tube, and brought back to the laboratory for examination. The examination consisted of dipping the brush into a few minums of decinormal sodium hydroxide solution

Table 2.—The Incidence of *Enterobius vermicularis* Ova in Dust of Public Buildings in Bloomington-Normal, Illinois, Area.

Public Buildings	Areas Studied	No. of Samples	No. of Positives	Percent
1. Schools	Cloak Rooms Rest Rooms Halls	23	0	0
2. Hospitals	Childrens Ward	8	0	0
3. Orphanages	Dormitories Toilet Rooms	101	12	11.8
4. Theaters	Auditorium Rest Rooms	3	0	0
5. Other Public Buildings	Conjested Areas	14	0	0
Total		149	12	8.1

on a deep-well slide and study of contents under a compound microscope. The ova having a lower density than that of the decinormal sodium hydroxide solution tended to float to the top. A few drops of the solution placed at the hilt of the brush and allowed to flow across it on to the slide seemed to be most effective as a means of cleansing the brush of the dust deposits. Each dust sample was examined three times. No attempt was made to determine the total number of ova present in any sample. In the scotch-tape method, a one and one-half inch strip of tape was placed over a surface and then carefully transferred to a clean slide. The slide was then examined under a compound microscope for ova.

Enterobius vermicularis ova were found in all stages of development from those of clear formative protoplasm with many vacuoles to full-grown embryos. Many of the embryos were in a partially disintegrated condition and their viability questionable. The eggs were clear and plain and were easily identified without staining. They measured from 50 to 60 microns by 20 to 30 microns and in general, were flat on one side with a distinct membranous covering.

The evidence from this study indicates that ova of the internal parasite, *Enterobius vermicularis,* are carried by air currents and may be inhaled, and thus be a source of infection and reinfection.

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THE INCIDENCE OF *ENDAMOEBA GINGIVALIS* IN A CENTRAL ILLINOIS COMMUNITY

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It was believed at one time that *Endamoeba gingivalis* was the causative organism of, or at least associated with, the condition known as pyorrhea. With the work of Dobell (1919), Craig (1926), and others who denied this claim, the organism has more recently been given a position of less importance as an etiologic factor in oral cavity disease. Investigators have repeatedly observed this protozoan in the mouths of humans, particularly at the base of the teeth. The present study was made on a group of dental patients (1) to supply further data relative to the occurrence of this organism in man and (2) to note further its relationship to different conditions of oral hygiene in persons of varying age levels.

According to Kofoid (1929) at least 75 percent of persons over forty harbor the organism *Endamoeba gingivalis*. The incidence of this organism found by L. W. Ritchie (1932) in the Chicago area ran as high as 80 percent in older age groups. Samples for the present study were obtained from 110 patients with the cooperation of a practicing dentist[1] in the city of Bloomington. Of the 110 samples examined, the following percentages of infection were obtained: Adults, 41.8 percent; teen-age, 11.1 percent; and children, 13.3 percent. The incidence of *Endamoeba gingivalis* in different types of mouths was: 100 percent in pyorrhea mouths, 78.3 percent in dirty mouths,[2] and 25.8 percent in mouths that showed evidence of good daily oral hygiene. The dentist was supplied with sterile cotton swabs, and scrapings were taken from the spaces between the teeth, around the region of the gum, and pyorrhetic absesses. The condition of the mouth was classified as clean, dirty, or pyorrhetic. The patients were divided further into child, teen-age, and adult groups. Since the examination of the scrapings could not always be undertaken immediately, the swabs were placed in small vials containing 1½ cc. of 0.85 percent physiological saline solution. To insure against change of temperature the vials were kept in an incubator at body temperature. In most cases examinations were made from 3 to 24 hours after the specimens were collected. Most active forms of the organism were found when the examination was made within 12 hours after the sample was obtained. In one instance a very active organism was found after the specimen had been in the incubator for 72 hours.

In the microscopic examination of the samples, oil immersion was used. The slides as well as the cover slips were placed in the incubator to prevent sudden shock due to changes of temperature. The swabs were taken from the vials and smeared on slides.

The size of active organisms var-

[1] We are indebted to Dr. D. L. Winquist for his cooperation in providing us with samples for study.

[2] Mouths which indicated poor daily oral hygienic care—decaying food particles between teeth; yellow film deposits and stains on teeth.

TABLE 1.—INCIDENCE OF *Endamoeba gingivalis* FOUND IN THIS STUDY OF THE BLOOMINGTON, ILLINOIS, AREA AND RITCHIE'S FINDING OF THIS ORGANISM IN CHICAGO, ILLINOIS.

Age Group	No. Exam.	Sex		Pyorrhea	Dirty	Clean	Percentage in Age Group	Age	Ritchie's %
Adults.....	86	Male	Pos.	4	6	7	41.8	50 and over	83.4
			Neg.	0	2	23		41-50	89.9
		Female	Pos.	1	11	8		31-40	80.7
			Neg.	0	2	23		21-30	72.8
Teen-age...	9	Male	Pos.			1	11.1	16-20	50
			Neg.			5			
		Female	Pos.			0			
			Neg.			3			
Children....	15	Male	Pos.		1	1	13.3	5-15	46.5
			Neg.		1	5			
		Female	Pos.			0			
			Neg.			6			
Percentage in type of mouth.....				100	78.3	25.8			

ied from 12 to 37 microns. The size may double in a matter of minutes and the shape varies constantly, at times being just an amorphous mass. The inactive organisms measured on the average 17 microns.

In appearance the endoplasm is usually crowded with food particles and granular material which seems to float in the center of fluid cavities. The ectoplasm is crystal clear. The pseudopodia are rounded and blister-like and flow out in the direction of movement, at times explosively and at other times very slowly. The granular endoplasm then flows into the transparent area. In active forms bacteria seem to adhere to the side opposite the pseudopodia, but in dead forms this adhesive force is lost. Bacteria were also noticed within the cytoplasm. On the slides containing numerous organisms there were fewer free bacteria present. This gives support to the theory that the organism ingests bacteria. Active forms were fixed in Bouins' solution, stained in haemotoxylin, and permanently mounted.

Table 1 shows percentages of infection found in this study in different types of mouths, age groups, and sex groups with Ritchie's findings listed for comparison. Since the patients studied represent a cross section of the area with respect to occupation as well as economic status, we feel that the data are highly indicative of the incidence of *Endamoeba gingivalis* in the mouths of persons in this central Illinois community.

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A NEW METHOD FOR STAINING CELLS WITH COBALT AND BAL

THEODORE N. TAHMISIAN AND AUSTIN M. BRUES
Biology Division, Argonne National Laboratory, Chicago

Cobaltous ions when used as a mordant form a colorless complex salt with the tissue constituents. The loci of cobalt complexes are rendered visible by developing them to a dark brown with BAL (2-3 mercaptopropanol).* Since a large amount of sulfur is present in the protoplasm and since cobalt has a high affinity for sulfur, we believe that the original complex formed when the tissue is mordanted in cobalt is a cobalt-sulfur complex. Another reason for believing that a cobalt-sulfur complex is formed is that a tissue treated as though prepared for an —SH test renders a better color.[1]

Compounds containing one —SH group do not form any color when cobalt is added unless the pH of the compound is 8.5 or higher. When a compound containing two or more —SH groups is added to cobalt a brown color is immediately obtained. H_2S and cobalt form a black sulfide.

This staining method is very useful for the fibrillar portions of the cytoplasm, especially for the staining of the mitotic spindle and centrioles. We wish to state that this is not a method for testing for the presence of —SH groups.

Fixation of material with trichloroacetic acid, 10 percent; formalin, 10 percent; Bouin's solution; Flemming-Strong solution; Allen's B-15 solution; Allen's B-20 solution; or Zenker's solution gives good results when stained by the cobalt-BAL method.

Blood for staining white cells is fixed in 100 percent alcohol 1 minute, dried quickly in air, and fixed in 10 percent trichloroacetic acid. The hot method of blood fixation by igniting the alcohol does not allow staining.

The procedure in general is as follows:

1. Fix and embed sections, mount material on slides (bleach if necessary with H_2O_2 as in Flemming-Strong technique).
2. Remove paraffin.
3. Hydrate to H_2O.
4. Place in 5 percent Zn $(Ac)_2$ 10 minutes.
5. Rinse 3 minutes.
6. Place in 3 to 5 percent Co $(NO_3)_2$ or any other cobaltous salt from 30 minutes to 12 hours.
7. Wash 1 to 30 minutes in running tap water.
8. Place in 35 percent alcohol containing 0.5 percent 2-3 mercaptopropanol. (*Note*: place the mercaptopropanol into 85 or 95 percent alcohol, then dilute to 35 percent alcohol and 0.5 percent BAL.)
9. Wash, dehydrate, clear, and mount.

If the material is placed alternately into cobalt and BAL, washing in water between cobalt and BAL

* We are indebted to Hynson Wescott and Dunning, Inc., Baltimore, Maryland.

1 Rapkine nitroprusside test for —SH groups. Techniques of Histo and Cytochemistry, Interscience Press, New York, 1949.

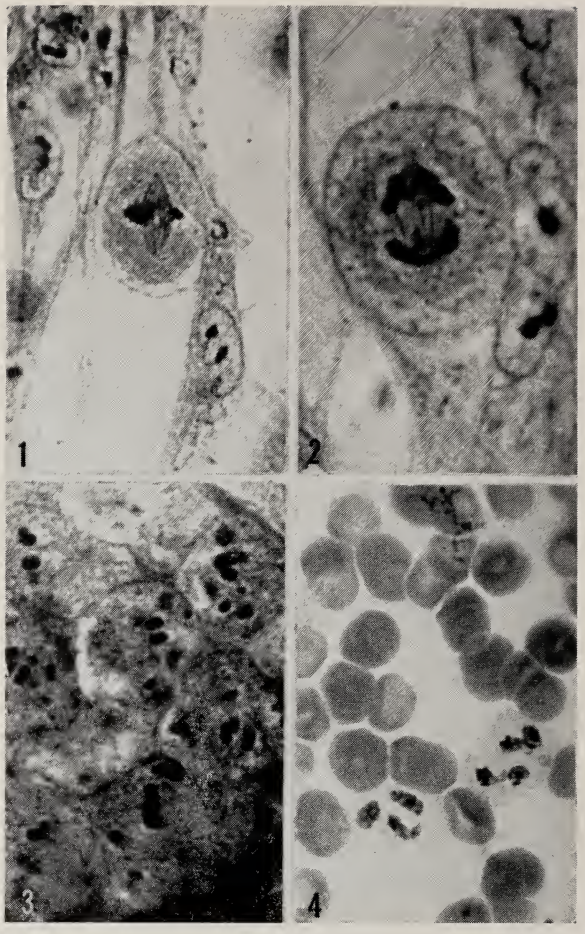

Fig. 1.—Metaphase spindle, tissue culture, chick heart fibroblasts.

Fig. 2.—Late anaphase, tissue culture, chick heart fibroblasts.

Fig. 3.—Late maturation division, grasshopper testis.

Fig. 4.—White cells, human blood.

and BAL and cobalt each time, the stain is strengthened infinitely.

Figures 1-4 are representative of this technique. The pictures were made using a micro-ipso attachment and 35-mm film.

COLLEGIATE SECTION*

THE STUDY OF CICATRIZATION IN PLANT TISSUES

DOLORES BRESINGHAM
Directed by Dimitri Sokoloff, Ph.D.
Mundelein College, Chicago

The purpose of this study was to observe the processes by means of which plants heal their wounds and protect the tissues in the vicinity of such wounds from harmful factors. The comparison was made of such processes in a small herbaceous land plant, *Oxalis,* and the water plant, *Elodea.* The leaves of the said plants were either cut with scissors or pierced with a needle so that the perforation passed entirely through the leaf. Then the operated leaves were cut off and fixed 10 minutes after the operation, 20 minutes, half an hour, one hour, two hours, and so on up to 24 hours, and then one day, two days, three days, and so on. The fixative used was almost exclusively acetic alcohol. However, in some cases the sublimate acetic was also used, as intended preparation to the Feulgen reaction. The stain used was exclusively the Harris Modification of Hematoxylin of Delafield. The leaves of both plants were thin enough to allow the total preparation, especially in the case of *Elodea.* In the case of *Oxalis,* which is less transparent, the method of microtome sections was sometimes used, the sections being prepared from 7 to 15 microns thick. These sections were also stained with Hematoxylin of Delafield, sometimes after sectioning, sometimes previously, staining the leaf in total and then preparing the sections. In all cases the stain was differentiated by means of alcohol acidulated with hydrochloric acid (2 drops per 100 cc.).

Another purpose of this study was to see if some kind of regeneration or new formation would take place at the operated points of the leaves as has been described in some cases, in *Begonia* and some other plants. During these experiments, no regeneration took place either in *Oxalis* or in *Elodea,* the process reducing itself to the formation of a protective layer. This process proved to be completely different in the land plant and in the water plant.

In the land plant, *Oxalis,* from the biological standpoint, showed nothing but rapid dying away of the cells surrounding the wounds owing to the rapid loss of water because the epidermis was destroyed on both sides of the leaf. The cells thus exposed to drying rapidly shrank, the protoplasm condensing while the central vacuole containing the cellular sap, and normally occupying the greater part of the cell, diminished and finally disappeared. The diminishing of protoplasm in volume caused the chlorophyll grains to be brought together and to become concentrated. Then the cell became an irregular body containing the nucleus, which also began to shrink in its central portion, but no process of any kind took place in them. Finally,

* The second paper in the Collegiate Section chosen for publication by the Committee was withdrawn too late for a replacement to be selected.—Editor.

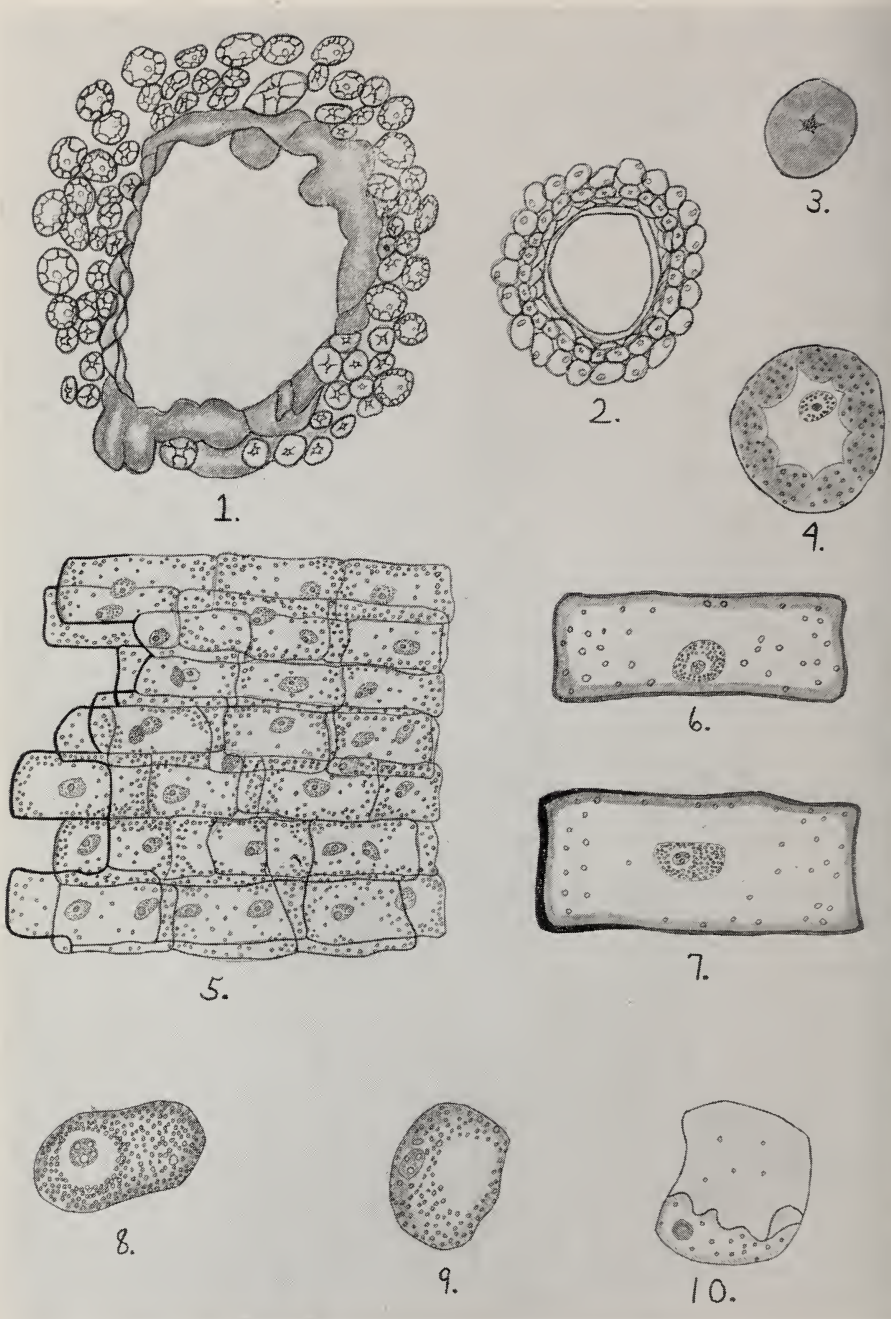

Fig. 1.—Partly schematized drawing of the perforated wound in a leaf of *Oxalis*.
Fig. 2.—Schematized drawing of the preceding.
Figs. 3. and 4.—Parenchyma cells of Oxalis at different stages of contraction owing to evaporation through the wound.
Fig. 5.—Drawing of a portion of an incised edge of an *Elodea* leaf.
Fig. 6.—Normal cell of *Elodea*.
Fig. 7.—*Elodea* cell with part of membrane thickened because of contact with water.
Fig. 8.—Normal nucleus of parenchyma cell of *Elodea*.
Fig. 9.—Beginning of degeneration of same.
Fig. 10.—Nucleus in advanced stage of degeneration.

the nucleus was completely crushed by the hardening protoplasm and the whole cell became a small irregular clot. The adjacent cells, undergoing a similar change, fused with it and all together formed a continuous layer of substance in which the individual cells could no longer be distinguished. However, for some time the remainder of the nuclei were still seen in stained preparation as irregular granular masses.

This layer of substance, mostly proteic in nature, was nothing but coagulated protoplasm, which also contained cellular walls and therefore was partly cellulose. Then it dried up and formed a hard crust completely covering the surface of the wound. Nevertheless, this protective layer seemed to be not quite adequate to stop the evaporation until it became thick enough. The whole process was very rapid, taking only 10 to 20 minutes. A few days following the operation, the protective layer extended itself over a few more layers of cells which underwent the change described. Here the process stopped, because of the sufficient thickness of the protective layer which prevented the further evaporation of the water.

Figure 1 is a drawing of the wound as it appeared in the leaf of *Oxalis* when pierced with a thin needle. Figure 2 is a schematic representation of the same wound. The first layer of substance which can be seen surrounding the opening is simply a mass of cells crushed by the needle. Outside of this is a layer of cells which died because of the loss of water due to evaporation, and which form a protective layer. Adjacent to the latter layer appear the cells which have already shrunk but still can be distinguished individually. Each nucleus is seen as an irregular stellate body in the center. The outside layer contains living cells not yet affected by the process. The formation of the first protective layer was exceedingly fast, taking place in 10 to 20 minutes; then the only change observed during an interval of time varying from several hours to several days was growth of the layer. No reproduction of the surrounding cells was observed nor any tendency toward the regeneration.

As a conclusion it can be stated that the healing process of the wound in this small herbaceous plant is not biological in nature and cannot be termed as a true cicatrization process because it is simply a physical one consisting of loss of water due to evaporation through the wound, accompanied first by coagulation and then drying up of the protoplasm of the affected cells. However, the fact that these cells fused together allows the formation of a quite adequate protective crust which prevents further evaporation on one hand and on the other gives an adequate protection against the penetration of bacteria and fungi. The only biological phenomenon which takes place is of a necrotic nature. It is a rapid dying away of the cells directly or indirectly affected by the lesion. The extreme rapidity of the formation of the protective layer permits a comparison of it to a certain degree with blood coagulation rather than with cicatrization. However, the elements involved and the nature of the process are entirely different.

A control experiment was carried on by submerging and perforating the plant in water. No formation of a protective layer took place under these conditions, while the exposed cells suffered the process of

gradual disintegration. Therefore, it may be concluded that the principal factor in the formation of the protective layer is the evaporation of water through the wound.

The second part of this work was directed to the study of the same process in a water plant, *Elodea*. The technique was essentially the same. The young leaves of *Elodea* were either cut or prickled and then fixed after regular intervals of time. The fixative and the stain was the same as for *Oxalis*. The process of the wound healing in this case proved to be entirely different than the one observed in the land plant, taking a considerably longer time, and being purely biological in nature and justifying the term "cicatrization." The cells adjoining the wound and exposed to direct contact with water did not die in most cases, but responded to the water stimulus by the thickening of that part of the cell wall which is exposed to such contact. In some cases, as can be seen on the illustrated figures, the cell wall became two or even three times thicker and also stained much more intensely than the ordinary cells. In some cases, it was also observed that the membrane became multilayered. This process of thickening or reinforcement of the membrane implies the local process of secretion, the whole response of the plant in this case being of a purely biological nature. Nevertheless, it must be observed that some cells apparently are unable to respond quickly enough and die away. Then the adjoining cells reinforce their walls and in this way stop the process of destruction. The nuclei of the cells which could not respond become more compact and refringent, later acquiring an irregular outline and finally being destroyed.

MEMORIAL

NEIL EVERETT STEVENS
1887-1949

In the death of Neil E. Stevens on June 26, 1949, at the age of 62, the Illinois State Academy of Science lost a supporter and friend whose interest in our organization was consistent and helpful during his thirteen years of residence in Illinois. Born in Portland, Maine, in 1887, he was educated at Bates College and at Yale University, which awarded him the Ph.D. degree in 1911. His professional career included one year of teaching at Kansas State College, 24 years in the Bureau of Plant Industry of the U. S. Department of Agriculture as plant pathologist, and 13 years at the University of Illinois as Professor of Botany, Head of the Department, and Professor of Plant Pathology in the Department of Horticulture. During his professional career, he was active in a number of scientific organizations, including the American Association for the Advancement of Science, the Botanical Society of America, the Mycological Society of America, and the American Phytopathological Society. He was president of the American Phytopathological Society in 1934 and of the Botanical Society of America in 1947, and served for a number of years on the council of the A.A.A.S.

Professor Stevens' most intensive research centered upon diseases of corn and cranberries, and his publications on these diseases are widely recognized and valued for their high scientific quality and their precise writing. His many-faceted personality and his extensive interests are

reflected in the numerous papers which he wrote on topics other than his major research interests. His friends and students, as well as those who never had the privilege of personal contact with him, will continue to gain mental stimulation and gentle amusement from his papers on the excessive politeness of American botanists, brevity at botanical banquets, scientific fads, bureaucracy as a way of life, the re-education of educators, and fun in research. His scientific interests, although centering upon plant diseases, were not limited to that field, for he published several papers on geology, paleobotany, and the history of American botanists and their works. His total bibliography comprises 176 papers, of which five were published in the Transactions of the Illinois State Academy of Science.

Those who knew Neil Stevens will remember him for his sparkling wit, his intense interest in students and in problems of teaching, his facile pen, his great human sympathies, and his abiding interest in science at all levels, in the high schools and small colleges, as well as in the great universities and scientific foundations. Though his contributions to American botany and to scientific education in general were extensive and fundamental, he was extremely modest and self-critical. The key to his philosophy of life is found in this gentle and moving inscription carved at his request upon his gravestone:

"To travel hopefully is a better thing than to arrive, and the true success is to labour."—Robert Louis Stevenson.

Harry J. Fuller

ACADEMY BUSINESS

SECRETARY'S REPORT OF THE BUSINESS OF THE ILLINOIS STATE ACADEMY OF SCIENCE FOR THE YEAR MAY 7, 1949 TO MAY 6, 1950

Compiled by LELAND SHANOR, *Secretary*

The 43rd annual meeting of the Illinois State Academy of Science was held at Rock Island on the campus of Augustana College May 5 and 6, 1950. Attendance at this meeting was somewhat over 500, of whom 319 registered officially, and approximately 400 attended the complimentary Smorgasbord provided by Augustana College to replace the usual Academy banquet. The sectional programs included 105 papers and over 480 people were in attendance at the sectional meetings. At the general session in the morning, Mrs. Jennie N. Smythe delivered an address on "A National Policy on Television" which was prepared for the Academy by her husband, Dr. Dallas W. Smythe, Institute of Communications Research, the University of Illinois, who at the last minute was unable to be present. Following the traditional Swedish Smorgasbord in the evening, the Augustana Choir, under the direction of Mr. Henry Veld, presented a very excellent program which contributed much to the pleasure of all attending the meeting. This concert was followed by a lecture on "Aboriginal Australia," illustrated with Kodachrome movies, by Mr. Frank M. Setzler, Head Curator of the Department of Anthropology, U. S. National Museum. The auditorium of the College Chapel was completely occupied for the concert and the annual lecture, except for a few seats in the balcony.

Those attending the annual meeting this year seemed to be in general agreement that, through the very gracious hospitality of Augustana College, the Rock Island High School, and the various other organizations in the tri-city area which contributed, the 1950 meeting can be regarded as one of the outstanding annual meetings of the Academy.

The past year, in many respects, has been a very good one for the Academy. Our membership has increased by approximately 150 new members. The Constitution and By-laws were carefully studied and a revision was passed unanimously by the Academy at the afternoon business meeting on May 5, attended by approximately 125 members. The revised Constitution and By-laws are attached as a part of the Secretary's report on Business of the Academy.

COUNCIL MEETINGS

The Council held four meetings during the past year. Dr. Thorne Deuel, newly elected President of the Academy, presided at the first meeting which followed the Council Breakfast, Saturday, May 7, 1949, in Galesburg. The invitations extended by Navy Pier and Augustana College to hold the annual meeting in May 1950 on their campuses were considered. The Council decided to accept the invitation of Augustana College and the Rock Island community, and Professor F. M. Fryxell, of Augustana College, was designated Second Vice-President of the Academy, to be in charge of local arrangements. It was suggested that the Academy establish a registration fee and provide such things as identification badges, etc., for members attending the meeting. The fee was left to be considered at a later council meeting, but the matter of items, such as badges, to be provided at the meeting was approved by the Council. The

Council passed a motion that the two best papers, or abstracts of papers, presented at the Collegiate Section, be included in the TRANSACTIONS. The general concensus of the Council seemed to favor the publication of two papers, if such papers were deemed worthy of publication when considered by the Committee on Publications.

The second meeting of the Council was held in Springfield, on October 22, 1949, with President Thorne Deuel presiding. The Council voted that a registration fee of 50c be charged those attending the meeting and that, at the time of registration, registrants be given copies of the program, information about the local community, and other materials that might be appropriate for the meeting. The Council also voted to print the names of sustaining members on the program of the annual meeting and urged the committee on sustaining memberships to endeavor to increase sustaining memberships to make additional funds available for Junior Academy activities. The Council considered a suggestion that the Constitution and By-laws needed revision and a committee was appointed to make such a study and to report the suggested revisions for Council approval at its next meeting in time to have a revision ready to submit for the action of the membership at the annual meeting in May at Augustana College. Following the report of the Chairman of the Conservation Committee, the Council approved a motion to go on record as favoring conservation of small areas and that the Academy might actively participate, as far as it could, in such projects. The attention of the Council was called to the severity of a disease of oaks, known as Wisconsin Oak Wilt, which is spreading into Northern Illinois, and is becoming an increasing menace to our native oak stands. The Council approved a motion that a letter, drawn up by Dr. L. R. Tehon and expressing the Council's feeling in the matter, be sent to certain government agencies, urging that additional funds be made available for the study of the disease and possible methods of controlling it.

President Thorne Deuel presided at the third meeting of the Council, held in Springfield on January 14, 1950. Reports of sectional chairmen on the progress being made in arranging the program for the annual meeting, a report by Dr. Fryxell on arrangements at Augustana College in Rock Island, and reports of chairmen of certain of the standing committees were presented. A preliminary report of the actions of the committee on the revision of the Constitution and By-Laws was given and several suggestions by members of the Council were incorporated in the draft which had been prepared. With these suggestions incorporated, the committee was directed to prepare copies of the revision to send to the membership, along with the program of the annual meeting, so that it could be acted upon at Rock Island. Because of the continued growth of the Junior Academy, certain problems have developed. Mr. George S. Porter, the General Chairman of the Junior Academy, suggested a plan whereby the State might be divided into regions for the purpose of holding regional exhibits prior to the annual meeting. Winners of these regional fairs then would bring their exhibits to the annual meeting. The General Chairman of the Junior Academy was authorized by the Council to proceed immediately with this plan, since similar plans have worked very well in other areas, such as music, debate, and similar activities.

The fourth meeting of the Council was held in Rock Island following the annual Council Dinner. President Deuel presided, and 24 people were present for this Council meeting. Sectional chairmen presented their final reports and the General Chairman of the Junior Academy reported on the program of that group. He pointed out that the proposed regional exhibits could not be initiated this year but would be attempted for 1951. Dr. Fryxell reported on local arrangements and called attention to certain changes that were necessary at the last minute. Dr. O. B. Young

presented a report to the Council for the Committee on the History of the Illinois State Academy of Science and had, for the approval of the Council, a manuscript on the early history of the Academy prepared by the chairman of the committee, Mr. W. M. Bailey. He asked that it be published in the Transactions of the Academy, since this early history of the Academy is no longer generally available. The Council approved the publication of this paper in the forthcoming issue of the Transactions. The Council went over the revision of the Constitution and By-laws as presented to the membership and had further changes to suggest before the revised copy was to be presented at the business meeting on Friday afternoon for Academy action.

REPORT OF THE TREASURER

For the Year May 1, 1949 to April 30, 1950

Balance on hand April 30, 1949	$ 1,051.53	
Less outstanding checks	4.81	
True Cash Balance		$ 1,046.72

Receipts

Dues:			
Annual members	$ 1,449.50		
Affiliated societies	4.00		
		1,453.50	
Interest on Meyer real estate		9.00	
Interest from U. S. Savings Bonds, Series G		37.50	
Libraries		2.00	
Sales of Transactions		14.00	
Sales of Reprints		110.40	
Research Grant by the A.A.A.S.		245.00	
Junior Academy—Sustaining memberships		270.00	
			2,141.40
Total Receipts			$ 3,188.12

Expenditures

Council Dinner and Breakfast—Galesburg	$ 73.19	
Local Chairman's Expenses	45.49	
Council Expenses During Year	77.06	
Treasurer's Office Expenses	25.50	
Secretary's Office Expenses	23.61	
Librarian's Expenses	104.56	
Section Chairmen's Expenses	8.04	
Science Talent Search Expenses	19.12	
Conservation Council	3.00	
Corporation Registration	3.00	
Secretary, Honorarium	150.00	
Editor, Honorarium	150.00	
Research Grants	245.00	
Junior Academy	419.71	
Total Expenditures		$ 1,347.28
Balance in Commercial National Bank of Peoria		1,840.84
		$ 3,188.12

Statement of Resources, April 30, 1950

Balance in Commercial National Bank of Peoria	$ 1,840.84
Certificate of Interest for Meyer Block Leasehold	Value Unknown
United States Savings Bonds, Series G	1,500.00
Total Resources	$ 3,340.84

(Signed) W. W. Grimm, *Treasurer*

REPORT OF THE COMMITTEE ON AUDITING

To The Illinois State Academy of Science:

Your committee on auditing respectfully submits the following report:

We have examined the records of the Treasurer, W. W. Grimm, for the year May 1, 1949 to April 30, 1950, and find them correct. The present financial status of the Academy is as follows:

Cash on deposit with the Commercial National Bank of Peoria	$ 1,840.84
Series G, U. S. Savings Bonds, fifteen (15)	1,500.00
Meyer Block Leasehold Certificate No. 15	(Value Unknown)
Assets	$ 3,340.84

(Signed) F. W. LUTTEY, *Chairman*
ALLAN K. SMITH
L. P. ELLIOTT

REPORT OF THE COMMITTEE ON RESOLUTIONS

Your Committee on Resolutions wishes to submit for your consideration the following resolutions:

I. The Illinois State Museum

Be it resolved, that the Illinois State Academy of Science hereby reaffirms its interest in the Illinois State Museum and the construction at the earliest possible date of a suitable and adequate State Museum building.

II. Junior Academy

Whereas—For several years Mr. George S. Porter has served as General Chairman of the Junior Academy of Science, with the full approval and cooperation of the J. Sterling Morton High School, of Cicero, and has achieved notable results in the stimulation of student interest and participation in science; therefore,

Be it resolved, that the Illinois State Academy of Science on the occasion of its 43rd annual meeting does express to Mr. Porter personally and to the J. Sterling Morton High School its appreciation for an outstanding contribution to the education of the youth of Illinois.

III. Rock Island Arsenal

Be it resolved, that the Illinois State Academy of Science expresses to Col. W. W. Warner, commandant of the Rock Island Arsenal, and to the Army Engineers its appreciation of the unusual opportunity to visit and inspect the Arsenal, during the occasion of the 43rd annual meeting of the Academy.

IV. Deere and Company

Be it resolved, that the Illinois State Academy of Science expresses to officials of Deere and Company its appreciation of the unusual opportunity afforded the Academy, on the occasion of its 43rd annual meeting, to visit and inspect the Company's plant at Moline, Illinois.

V. Davenport Museum

Be it resolved, that the Illinois State Academy of Science expresses its appreciation to Mr. Fred Hall, Director of the Davenport Public Museum, for courtesies to the Archeological Section, on the occasion of the 43rd annual meeting of the Academy.

VI. Mr. Carl Gamble

Be it resolved, that the Illinois State Academy of Science extends sincere thanks to Mr. Carl Gamble for courtesies rendered the Academy and especially for the opportunity to visit his astronomical observatory on the occasion of the 43rd annual meeting of the Academy.

VII. Rock Island High School

Be it resolved, that the Illinois State Academy of Science expresses its appreciation to the Principal, Mr. Owen B. Wright, of the Rock Island High School, to Mr. George McMasters, Biology Teacher and local chairman for the Junior Academy, and to their collaborators for many labors contributing to the success of the Junior Academy exhibits and other sessions on the occasion of the 43rd annual meeting of the Illinois State Academy of Science.

VIII. Chamber of Commerce

Be it resolved, that the Illinois State Academy of Science expresses its appreciation to Mr. W. L. Keepers, Secretary of the Rock Island Chamber of Commerce, for many courtesies rendered during the 43rd annual meeting of the Academy at Augustana College.

IX. Junior Academy Banquet

Be it resolved, that the Illinois State Academy of Science expresses its grateful appreciation to the ladies of St. John's Lutheran Church, who under the leadership of Mrs. George Myer provided the banquet for the Junior Academy on the occasion of the 43rd annual meeting of the Academy, at Augustana College.

X. Augustana College

Whereas: Augustana College, through its Board of Directors, its President, Dr. Conrad Bergendoff, Professor F. M. Fryxell, Chairman, and the several and individual members of the Committee on Local Arrangements, has so cordially invited the Illinois State Academy of Science to hold its present and 43rd annual meeting on the Augustana College campus during the 75th anniversary of the founding of the College, and

Whereas: the College, Dr. Fryxell and his committee, and many faculty members and students have labored diligently to provide necessary facilities and make needed arrangements, and have given generously in time and effort to bring about an outstandingly successful meeting; therefore,

Be it resolved, that the Illinois State Academy expresses its sincere thanks for all efforts in its behalf, adds its compliments on arrangements especially well planned and carried out, and expresses its deep appreciation of the exceptionally cordial and gracious hospitality that has been offered.

XI. Smorgasbord

Be it resolved, that the Illinois State Academy of Science extends hearty and appreciative thanks to Mrs. David Beckstrom and her assistants for planning preparing, and serving the traditional Swedish Smorgasbord, an outstanding and happy feature of the 43rd annual meeting of the Academy at Augustana College.

XII. Augustana Choir

Be it resolved, that the Illinois State Academy of Science, on the occasion of its 43rd annual meeting, expresses its grateful appreciation to Mr. Henry Veld, conductor, and the Augustana Choir for an outstanding musical contribution to this meeting of the Academy.

XIII. Augustana College Band

Be it resolved, that the Illinois State Academy of Science, on the occasion of its 43rd annual meeting, expresses its grateful appreciation to Mr. Robert D. Gaskill, conductor, and the Augustana College Band for an outstanding musical contribution to this meeting of the Academy.

XIV. Secretary

Be it further resolved, that the Secretary is instructed duly to enter the foregoing resolutions on the minutes of the Academy and to transmit copies of the several resolutions to the parties concerned.

(Signed) LEO R. TEHON, *Chairman*
HARRY J. FULLER
CLARENCE R. SMITH

REPORT OF THE NECROLOGY COMMITTEE

Whereas: During the past year the Illinois State Academy of Science lost, by death, the members listed below:

A. J. Demster
R. E. Harris
C. R. Moulton
Clarence O. Sappington
Emil A. Siebel
A. M. Simpson
Neil E. Stevens
L. O. Trigg

Be it resolved: (1) That the Academy expresses its grief over their passing, and (2) That it extends its sincere sympathy to their families, to whom the Secretary is directed to write letters indicating our sense of loss while we extend our sincere sympathy.

(Signed) A. GILBERT WRIGHT
GEORGE D. FULLER

CONSTITUTION AND BY-LAWS ILLINOIS STATE ACADEMY OF SCIENCE

(Revised through May 5, 1950)

CONSTITUTION

Article I. Name

This Society shall be known as The Illinois State Academy of Science.

Article II. Objects

1. The objects of the Academy shall be the promotion of scientific research, the diffusion of scientific knowledge and scientific spirit, and the unification of the science interests of the state.

Article III. Members

1. *Active members* have the privilege of: Attending meetings, voting, holding office, presenting papers at meetings of the Academy, having such published if they are accepted by the Committee on Publication, and receiving copies of all publications of the Academy. Active members of the Academy shall be as follows:

a. *Life members* shall be those who have paid fifty dollars to the Academy as life membership dues, or have completed the payment of the stipulated requirement for life membership before May 6, 1950. Life membership dues shall be placed as a permanent fund and only the income is to be used.

b. *Annual members* shall be those who pay the annual membership dues.

2. *Student members* shall be those undergraduate college students who are elected to membership on recommendation of a college faculty sponsor who is a member of the Academy. Student members shall have the privileges of active members except they may not hold elected office in the Academy.

3. For election to active or student membership, the candidate's name must be proposed by two members, be approved by a majority of the Committee on Membership, and be acted upon favorably by a majority vote of the Council.

4. The dues for annual membership in the Academy shall be two dollars per year. Annual dues for student members shall be one dollar.

5. *Sustaining members* shall be those individuals or affiliated societies or other organizations who pay an annual dues of ten dollars or more. Funds derived from sustaining memberships are to be used by the Academy to help further the program of the Junior Academy in such manner as the Council of the Academy shall determine by majority vote.

6. *Charter members* are those who attended the organization meeting in 1908, signed the Constitution, and paid dues for that year.

Article IV. Officers

1. The *elected officers* of the Academy shall be a President, a First Vice-President, a Secretary, and a Treasurer. These officers shall be chosen by ballot at the time of the annual meeting and shall hold office for one year, or until their successors qualify.

2. The above officers shall perform the duties usually pertaining to their respective offices.

3. Ex-officio and appointive officers shall be a Second Vice-President, a Librarian, and Delegates to the A.A.A.S. and to the Conservation Council.

4. The *Second Vice-President*, who may be a resident of the community in which the next annual meeting is to be held, shall be appointed by the Council each year when the place of the next meeting has been decided upon, in order that he may serve as the ex-officio chairman of the *Committee on Local Arrangements*.

5. The Chief of the State Museum Division of the Department of Registration

and Education of the State of Illinois shall be the *Librarian* of the Academy.

6. The *Librarian* shall have charge of all the books, collections, and material property of the Academy, and shall serve as archivist of all official records and documents of the Academy. The Librarian shall have charge of the distribution, sale, and exchange of the published *Transactions* of the Academy under such restrictions as may be imposed by the Council.

7. *Auditing Committee.* The presiding officer shall, prior to each annual meeting, appoint a committee of three who shall examine and report in writing upon the accounts of the *Treasurer.*

8. Three *recent past officers* of the Academy shall be elected to serve as active members of the Council of the Academy.

Article V. Council

1. The Council shall consist of the elected officers of the Academy, the Second Vice-President, the Librarian, three recent past officers of the Academy, the General Chairman of the Junior Academy, and the Coordinator of the Collegiate Section. It shall be the duty of the Council to plan the annual meetings. To the Council shall be entrusted the management of the affairs of the Academy during the intervals between regular meetings.

2. The Council shall meet on call by the President of the Academy.

3. The Council shall ordinarily hold four meetings during the year, one just prior to the annual meeting of the Academy, one as shortly after the annual meeting as is convenient, and two others, normally in November and January.

Article VI. Meetings of the Academy

1. The regular meetings of the Academy shall be held at such time and place as the Council may designate. Special meetings shall be called by the President upon written request of twenty members.

Article VII. Publications

1. The regular publication of the Academy shall be the *Transactions* of the Academy.

2. The payment of dues entitles all members, except in the case of emergency, to receive the currently published *Transactions* of the Academy, but no member in arrears shall receive the published *Transactions* of any year for which he is or remains in arrears.

Article VIII. Foundation Fund

The Treasurer shall maintain a permanent fund for the Academy, only the interest on which may be used. This permanent fund shall consist of (1) life membership dues, (2) donations, and (3) funds as the *Council* may see fit from time to time to add from accumulations in the treasury.

Article IX. Affiliation

The Academy may enter into such relations of affiliation with other organizations of appropriate character as may be recommended by the *Council,* and may be ordered by a three-fourths vote of the members present at any regular meeting.

Article X. Amendments

This constitution may be amended by a three-fourths vote of the membership present and voting at an annual business meeting, provided that notice of the proposed change has been sent by the Secretary to all members at least twenty days before such meeting.

BY-LAWS

I. Order of Business

The regular order of business shall include the following:

1. Call to order
2. Reports of officers
3. Reports of standing committees
4. Election of members
5. Reports of special committees
6. Appointment of special committees
7. Unfinished business
8. New business

9. Election of officers
10. Program
11. Adjournment

II. Notice of Meetings

No meeting of the Academy shall be held without thirty days previous notice by the Secretary to all members.

III. Quorum

Fifteen members shall constitute a quorum of the Academy. Six members of the Council shall constitute a quorum of the Council.

IV. Incurrence of Bills

No bill may be incurred against the Academy by officers or committees in excess of twenty-five dollars, except as provided for in By-law X, unless approved by the President and the Secretary.

V. Dues

1. Dues are payable on or before the date of the annual meeting.

2. Members who, after having been duly notified by the Treasurer, shall fail to pay their dues on or before the date of the annual meeting of any year shall be considered in arrears and if they remain so shall have their names stricken from the membership roll on December 31st of that year.

VI. Standing Committees

1. The standing committees of the Academy shall be a Committee on Budget, a Committee on Affiliations, a Committee on Conservation, a Committee on Membership, a Committee on Publications, a Committee on the Junior Academy, and such others as the Academy shall from time to time deem desirable.

2. These standing committees shall consist of members chosen annually by the Academy, except for the Committee on Publications.

3. The Committee on Publications shall be appointed by the Council of the Academy and shall consist of six members representing several Sections of the Academy. Two members of this committee shall be appointed for terms of three years, two members for terms of two years, and two for a term of one year. As terms of these members expire, the Council at its meeting just prior to the annual meeting of the Academy, shall make appointments for three year terms. In case of a vacancy the Council shall appoint someone to fill the unexpired term.

4. The Committee on the Junior Academy shall manage the affairs of the Junior Academy with the advice and approval of the Council of the Academy.

5. The Coordinator of the Collegiate Section, who is elected by the Academy, with the assistance of a committee if it seems desirable, shall cooperate with the officers elected by the Collegiate Section in conducting the affairs of that body, subject to the advice and approval of the Council.

VII. Sections of the Academy

1. For the annual meeting of the Academy, there may be Sections for the presentation of programs as follows: Anthropology, Botany, Chemistry, Geography, Geology, Physics, Psychology and Education, Social Sciences, Zoology, Collegiate.

2. Other sections may be added on request by ten active members of the Academy and with the approval of the Council.

3. Members of the Academy shall indicate in which section or sections they are particularly interested.

4. Those members present at any section meeting during the annual meeting of the Academy shall constitute a quorum of the section.

5. They shall elect a chairman for the ensuing year.

VIII. Editing of Publications

1. The editing of the *Transactions* and of any other publications which the Academy may authorize shall be a responsibility of the Committee on Publications. It shall be the duty of this committee to pass on the merit of papers submitted for publication, select a technical editor, and establish, with the approval of the Council, editorial policy.

2. A Technical Editor of the *Transactions* shall be appointed by the Council upon recommendation of the Committee on Publications. The Technical Editor shall receive a small honorarium, the amount to be determined by the Council and approved by the Academy. The Technical Editor shall carry out policy determined by the Committee on Publications.

IX. Regulations Regarding Papers

No paper shall be entitled to a place on the program unless the manuscript or an abstract of the same shall have been previously delivered to the Secretary. No paper shall be presented at any meeting by any person other than the author, except on vote of the members present at such meeting. Manuscripts of papers intended for publication must be handed to the Secretary at the time of the annual meeting. Except by invitation of the Council, no paper can be accepted for publication unless the author is a member of the Academy or an applicant for membership. No paper shall be accepted for publication which has already been published elsewhere.

X. Officers' Expenses

The Secretary and the Treasurer shall have their expenses paid from the treasury of the Academy while attending Council meetings and annual meetings. Other members of the Council may have their expenses paid while attending meetings of the Council, other than those in connection with annual meetings.

XI. Robert's Rules of Order

Robert's Rules of Order shall cover all situations not specifically provided for in the Constitution or By-laws of the Academy.

XII. Suspension or Amendment of By-laws

These by-laws may be amended or suspended by a majority vote of the members present and voting at any business meeting.

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